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PLANT AND ENTOMOLOGICAL SCIENCES
I CROP PRODUCTION

ANNUAL REPORT OF THE
NATIONAL RESEARCH PROGRAMS
1977

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FOREWORD

I Crop Production

Research under Program Element 677, Crop Production Efficiency Research has been divided into two parts. Part I includes research under 15 National Research Programs (NRP) in Crop Production and Part II deals with research under 9 Crop Protection NRP's. Each part also includes 2 Special Research Programs (SRP).

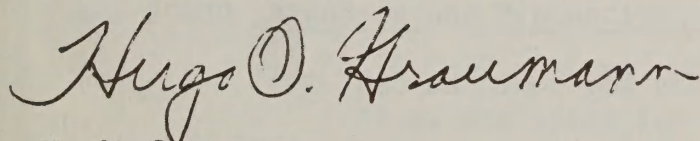
Research is conducted to improve plant productivity through improved varieties of food, feed, fiber, forage, florist and nursery crops, and turf to develop new crop resources and to develop improved crop production practices. Current emphasis is on research to develop new genetic stocks and varieties, increase yields and quality of crops, improve mechanization and crop production practices and to alleviate the effects of adverse environmental conditions through hardier plants.

New multidisciplinary concepts for increasing our productive capacity have been initiated. Special emphasis has been placed on improving basic photosynthetic processes in plants, natural nitrogen-fixing processes in soils and plants, better use-efficiency of both renewable and non-renewable energy resources, and control of plant growth and development.

The research workers in the Plant and Entomological Sciences publish the results of their investigations in the open literature as quickly as sound judgment warrants. The purpose of this report, however, is to provide for those interested in the results of this work, a brief overview of the scope of the activities and examples of recent findings, some of which still have not been released by publication. No attempt is made at completeness.

This report outlines the research for which the Plant and Entomological Sciences Staff is responsible and provides a brief description of recent accomplishments at the various locations throughout the United States. The report is organized by SEA National Research Programs, each of which describes a separate subject matter area. The SEA National Research Programs are subdivided into Technological Objectives which more specifically describe the objectives of each area of research.

Readers who have comment or inquiries are invited to contact either the National Program Staff or, more appropriately, scientists at the locations where the research is conducted.



H. O. Graumann
Acting Assistant Administrator
Plant and Entomological Sciences

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SUMMARY

Plant and entomological sciences research is an integral part of the total research program in the Science and Education Administration. Research is conducted to improve plant productivity through improved varieties of food, feed, fiber, forage, florist and nursery crops, and turf to develop new crop resources and to develop improved crop production practices. Current emphasis is on research to develop new genetic stocks and varieties, increase yields and quality of crops, improve mechanization and crop production practices and to alleviate the effects of adverse environmental conditions through hardier plants. New multidisciplinary concepts for increasing our productive capacity have been initiated. Special emphasis has been placed on improving basic photosynthetic processes in plants, natural nitrogen-fixing processes in soils and plants, better use-efficiency of both renewable and non-renewable energy resources, and control of plant growth and development.

The research is described under 15 National Research Programs (NRP) and 2 Special Research Programs (SRP).

A brief summary of each NRP and SRP is provided in the front of this volume. More detailed reports for each NRP and SRP follow with selected examples of progress and publications.

NRP 20010 Breeding and Production - Fruits, Nuts, and Specialty Crops

The objectives of this National Research Program are to develop new improved varieties for fruits, nuts, and specialty crops and to develop new improved cultural and management practices for these crops. This research is presently being conducted at 16 locations by 50 scientists in several disciplines and serves many small and diverse horticultural industries. Research reported in this annual summary is also reported in 128 separate scientific articles. This current research includes highlights on (1) introduction of new improved pest-resistant varieties with increased consumer acceptance, (2) genetic studies on mode of inheritance of horticulturally important fruit and plant characteristics, (3) survey information on genetic resources available for use by those conducting breeding programs, (4) improved techniques for applied fruit breeding, (5) cultural practices to increase yields and reduce cost of production, (6) improved methods of disease control, particularly viruses, (7) new rapid procedures for indexing plant material for viruses and virus-like disorders, (8) physiology studies on plant growth, flowering, and fruiting, and (9) new and improved methods of plant propagation.

NRP 20020 Breeding and Production - Vegetables

This program emphasizes research in breeding and production of vegetables to develop new and improved genetic and cultural methods that will result in lowering costs of vegetables and potatoes to consumers and increasing efficiency of production of these crops to growers, small acreage farmers, and homeowners. Geneticists, plant pathologists, plant physiologists, and horticulturists (both Federal and State) work in a team approach to evaluate and improve vegetables and vegetable cultural methods.

New cultivars developed and released during the past year included a new carrot with higher dissolved solids, vitamin A and sugar content; a new disease resistant seedless cucumber; a green-seeded lima bean for home gardens; a mechanical-damage resistant dry bean; an edible-podded pea; high quality disease resistant iceberg lettuce; a new long russet potato for the Northwest; and a high yielding disease resistant potato for the eastern States, along with the first russet potato variety for the Northeast, and a home garden type tomato where the southern root-knot nematode is a problem.

Many new breeding lines were also developed and these included anthracnose resistant lima beans, insect resistant cowpeas, disease resistant snap beans, new canning pea lines, cantaloupe lines with higher vitamin C content and other lines with resistance to powdery mildew, a sweet potato with resistance to all known biotypes of the southern root-knot nematode, new processing tomato lines and others with anthracnose resistance, and for the Western U.S. tomato lines with resistance to curly top. In other breeding research, genes for many desirable traits were identified such as: resistance to seedling fungal diseases in peas, heat tolerant germ-plasm in lentils, three new sources of male sterility in onions, lettuce lines with resistance to big vein, potatoes with higher vitamin C content, and some insights into the inheritance of toxic glycoalkaloids in wild potatoes.

NRP 20030 Breeding and Production - Florist and Nursery Crops

The major emphasis of this program deals with the multidisciplinary research to develop new technology for improving productivity and increasing efficiency in the production of florist and nursery crops to enhance urban and rural environments. This need for new knowledge makes it essential to provide research results on selecting, improving, protecting, maintaining, and cultivating plants for urban and rural home, landscape, and special purpose plantings such as parks, roadside, and shopping centers. Progress for this year included the development and release of two Pyracantha cultivars with multiple disease resistance to scab and fire-blight. A new flowering pear tree was released which is resistant to fireblight and has a narrow columnar crown making it ideal for small suburban yards and other limited spaces. Three introduced Painted Impatiens cultivars were released all having variegated foliage, large and intensely colored flowers, and everblooming habit.

It was determined that field windbreaks in the Northern Great Plains with proper soil and water management increased the yield of protected irrigated wheat 22 percent compared to crops not protected by windbreaks.

Another phase of the research in this program deals with improved cultural and management practices that increase yield, minimize losses, and improve quality. A variety of new developments are reported. Thirty-four kinds of plants were shown to grow more readily with new low-energy, high-intensity light sources. These will enhance plant growth in greenhouses, nurseries, malls and homes. New growth regulators to control regrowth along powerlines were tested and improved techniques developed to apply systemic pesticides to control Dutch Elm Disease. Improved methods were found that control powdery mildew of roses in production greenhouses. It

was found that the addition of mycorrhizal fungi to rooting medium enhanced rooting of several woody plant cuttings.

NRP 20040 Breeding and Production - Corn, Sorghum and Millets

Several hundred exotic corn races have been screened in a cooperative program carried out at 5 locations. Selected races having good resistance to one or more disease organism or insect pest and reasonably good adaptation for agronomic traits and yield are being crossed to form base populations for selection improvement programs.

Empirical and simulated studies indicate that complete dominance of favorable alleles best explain the results of reciprocal recurrent selection for yield. Recurrent selection to increase gene frequency of favorable genes governing grain yield, protein content, lysine content, and grain quality has continued.

Five inbred lines of corn with potential use in commercial hybrids have been released. An additional 5 lines were released for germplasm use in breeding program and contribute either insect or disease resistance or high yield factors.

Studies of genetic control of isozyme variants in corn now indicate about 20 loci involved and three loci have been located on individual chromosomes. Genetic differences for aflatoxin production potential exist among corn genotypes. Differences also were significant among commercial hybrids in supporting sporulation of Aspergillus flavus.

Research has continued on different sources of cytoplasmic male sterile sorghum systems. One new male sterile line was released and distributed to 60 private and public breeders. One sudangrass population resistant to downy mildew was released for breeding purposes.

In desiccation studies sorghum plants lost 25% in photosynthesis and yield was reduced 45%. Screening trials selected experimental strains showing 23% more drought resistance than the standard hybrid.

Sorghum lines have been shown to differ with respect to both phosphorus and nitrogen efficiency uptake from soil.

NRP 20050 Breeding and Production - Small Grains

Primary emphasis is placed on basic and applied research directed toward improvement of varieties of wheat, oats, barley, and rice, so that new varieties will produce more grain per acre, will have more effective protection from diseases and insects, will be better able to withstand environmental adversities, and will produce better quality and more nutritious grain for food and feed. Research is conducted at 26 locations, involving approximately 63 SY's. In 1977, wheat was grown on 74,804,000 acres, oats on 17,793,000 acres, barley on 10,586,000 acres, and rice on 2,261,000 acres in the U.S. Rye was grown on an additional 2,652,000 acres and very small acreages of triticale, wild rice, and buckwheat were produced. All are included in NRP 20050.

NRP 20060 Breeding and Production - Cotton

The mission is to develop new knowledge which will increase the production efficiency of this basic crop and provide consumers with a stable supply of fiber and food at a reasonable cost. Research approaches emphasize genetic improvement and the development of more efficient cultural and management practices. The research is being conducted at 14 locations across the Cotton Belt. Eight breeding stocks were released including 4 lines with resistance to root knot nematodes, 3 strains which suppress bollworms and budworms, and 1 glandless (gossypol-free) strain for improving seed quality and processing efficiency. Two commercial varieties were released; Acala SJ-5 for the California area, with improved yield and Verticillium wilt resistance, and SC-1 which combines high yield and superior fiber quality for production in the Southeast. Natural pesticides were identified in the pigment glands of the cotton plant and preliminary studies indicate that resistance of cotton to pests can be improved by genetic manipulation of these natural substances. Two new wild species of cotton were added to the germplasm collection. Significant advances in cell and embryo culture techniques were reported, although regeneration of plantlets from tissue cultures has still not been achieved. Special emphasis is being given to basic research on photosynthesis, water relations, and growth regulation in the cotton plant.

NRP 20070 Breeding and Production - Tobacco

Emphasis is placed on developing genetic, cultural, and curing procedures that modify tobacco leaf so as to reduce leaf and smoke constituents active in certain bioassay systems while retaining those components that contribute to flavor and aroma. Growth regulators, chemical and non-chemical pest control methods, and pest resistant cultivars are being developed that will increase production efficiency and minimize chemical residues on the raw product. This research is conducted at six locations and involves about 25 SY's. A new curing procedure, homogenized leaf curing (HLC), reduced biological activity of tobacco smoke in preliminary tests and permitted extraction of soluble proteins, Fraction 1 and Fraction 2, with high nutritive value as byproducts. Cultural and genetic manipulation of tobacco resulted in reduced levels of several chemicals in the leaf and their combustion products in the smoke that are biologically active in test systems. Natural growth regulators from higher plant material showed promising tobacco sucker control action; and an experimental chemical, CGA-41065, was equal to the standard, maleic hydrazide, in regional sucker control tests. Antagonism between certain non-pathogenic organisms and Alternaria alternata, the brown spot pathogen, aided in the control of brown spot disease. Four disease-resistant varieties, resistant to as many as five diseases, will enable flue-cured, burley, cigar and dark fire-cured growers to produce high yields of good quality leaf at reduced risk to crop losses. The breeding line NC PY 10 will aid in the development of new varieties yielding lower amounts of undesirable polynuclear aromatic hydrocarbons in the smoke.

NRP 20080 Breeding and Production - Soybeans, Peanuts, and Other Oilseed Crops

Primary emphasis is placed on the improvement of oilseed crops by genetics and breeding and by cultural and management practices. Soybean, peanut, and other oilseeds production research is conducted at 11, 4, and 6 locations, respectively; the total number of locations for oilseeds production research is 18. Approximately 32, 8, and 10 SY's are assigned to soybeans, peanuts, and other oilseeds, respectively, representing the disciplines of plant genetics, agronomy, plant pathology, plant physiology, microbiology, chemistry, entomology, and soil science. Most of the research is highly cooperative with State Agricultural Experiment Stations. The highlights of 1977 included: (1) Cooperative releases of 10 varieties of soybeans ranging in adaptation from Canada to the Texas Gulf Coast, two varieties of peanuts, and a breeding line of safflower; (2) The discovery of resistance to aflatoxin in peanuts; (3) The establishment of a sunflower species germplasm collection; and (4) The identification of a new plant fatty acid.

NRP 20090 Breeding and Production - Sugar Crops

Major emphasis in the program is on breeding to improve performance of sugarcane and sweet sorghum varieties and to develop improved breeding lines and hybrids of sugarbeet. Secondary emphasis is on developing cultural and management practices to increase sugar and sirup yields, minimize production losses, improve quality attributes, and efficiently conserve scarce resources in production systems involving the three crops. This research is conducted by 36 scientists at 10 locations. A total of about 730,000 acres of sugarcane is grown in 4 States. Approximately 1.3 million acres of sugarbeet are grown in 18 States. Sweet sorghum is grown for sirup production in several south-eastern States and has potential for sugar production, but current supply and low sugar prices prevent its adoption.

Sugarcane variety CP 70-1133 was released for commercial production in Florida. It yielded 29% more sugar per acre than the major commercial variety. Research in Louisiana demonstrated that yield increases of 60 to 70 percent can be achieved by reducing row spacing from 6 feet to 2 feet. In Hawaii, low levels of gibberellic acid reduced the effect of winter stunting by 50% and increased sugar production by 0.7 ton per acre.

There were 47 improved breeding lines of sugarbeet released for use by private breeders. Resistance to Erwinia soft rot, the major cause of short term storage losses in California, was identified and incorporated into hybrid components. Substantial progress was made in determining effect of Cercospora leaf spot. Two toxins produced by the fungus and two chemicals produced by infected plants were isolated and purified.

NRP 20100 Breeding and Production - Forage Crops for Hay, Pasture and Other Uses, Including Turf

A major emphasis is being placed on the development of improved forage germplasm, and 12 new releases were made during 1977. These include 4 alfalfa cultivars, 6 alfalfa breeding lines, and 2 buffelgrass cultivars.

Infrared reflectance spectrometry continues to show promise for the rapid and precise prediction of forage quality. However, more information is required concerning the effect of plant species, stage of plant development at harvest, growth environment, method of preservation, and sample preparation on spectral properties of forages. The relation between chemical and physical properties of different forages and infrared spectral values requires clarification to further validate and enhance the technology for forage evaluation.

The use of improved pasture management systems can increase the amount and efficiency of red meat production while conserving our soil and water resources.

The substitution of a pure legume, birdsfoot trefoil, for one-third of a conventional alfalfa-grass system in the North Central Lake State area resulted in 23 percent faster animal gains and 18 percent more animal gain per hectare. The improved animal performance can be traced to the greater intake and digestibility of the pure legume.

In the Southern Corn Belt, cattle gains during the hot summer months were 0.8 to 1.5 lb per day when grazing perennial warm-season grasses, such as Caucasian bluestem and switchgrass. This compares with poor gains, and even losses up to a pound per day, from cattle grazing cool-season temperate grasses such as tall fescue or orchardgrass. Cattle can be expected to gain weight throughout the entire grazing season on pasture systems where cool-season forages are grazed during spring and autumn, and the warm-season grasses grazed during the summer.

In the Southeast, mixtures of annual and perennial clovers provide the greatest seasonal distribution of yield and higher total forage production. Spring yields of mixtures were from 30 percent to over 60 percent higher compared to growing the annual clovers separately.

NRP 20110 Improved Vegetation and Management Practices for Range

Evaluation is underway of new germplasm collected during recent exploration trips. The material will serve as base populations for plant breeding programs. The survival of alfalfa seeded at a range site in northern Utah in the mid-50's lends promise to the potential for developing an improved alfalfa cultivar for rangeland.

Techniques were developed and tested to enhance the measurement, selection, and management of plants with improved growth and persistence for range. Studies included the nondestructive measurement of green biomass, measurement of root surface area, leaf surface variation in wax crystal morphology, seedling establishment by punch seeding, defining germination requirements of native range species, and water ponding to increase available soil moisture.

The renovation of overgrazed mixed prairie rangeland with 40 pounds per acre of actual N per year provided an increase of over 30 percent in carrying capacity and an additional 100 pounds gain per animal. The management practice is being adopted under actual ranching conditions and is applicable to several million acres of range in the Northern Great Plains.

The use of integrated forage production systems on range, including such combinations as native range, native meadow forages, improved introduced range species, and irrigated pastures, consistently improves range carrying capacity, calf production, and beef production.

Research within the sagebrush-bunchgrass zone has shown that the dietary overlap between antelope, deer, wild horses, cattle, and sheep on a typical desert wintering area is limited to grass in early spring and fall months. Such information will assist range and wildlife managers in programming resource allocations.

NRP 20160 Introduction, Classification, Maintenance, Evaluation, and Documentation of Plant Germplasm

The thrust of this program is to rescue disappearing germplasm resources from many parts of the world, maintain them in good condition, make them readily available to users who are improving and protecting our crop agriculture, record in retrievable form vast amounts of information on them so that we can be more efficient in their assembly, maintenance, and use, and preserve them for the use of future generations. This research is being conducted in 23 locations, involving approximately 55 SY's.

NRP 20170 Physiological and Biochemical Technology to Improve Crop Production

This program emphasizes research which will yield data elucidating the basic function of plants at the physiological and biochemical level. This new data will be used to establish advanced agricultural technology with emphasis on field and horticultural crops. The major emphasis of the National Research Program is to: (a) Improve the photosynthetic capability, photosynthetic efficiency, translocation, metabolism, and biological conversion of solar energy by plants. (b) Develop improved efficiency of nitrogen fixation and the absorption, translocation, and utilization of nutrients. (c) Improve crop production under environmental stress and reduce stress damage to plants. (d) Improve technologies for understanding water relations, seed germination, growth regulation, flowering, fruiting, and photoperiod as a base for using molecular biology to increase crop production efficiency.

Forty-three scientists working at twelve locations and supported by approximately \$4.7 million are engaged in this research activity. The research teams are made up of experts who represent both fundamental and applied sciences so that the transfer of basic information to field application may be optimized.

NRP 20180 Crop Pollination and Honey Production

Many plants in nature and many important fruit and seed crops depend on bees for pollination. Problems such as inadequate pasture, pesticide losses and diseases confront the long-range survival of wild bees and the profitable keeping of honey bees. This research is designed to help assure the survival of bees and beekeeping. It is concerned with improved methods of management; greater knowledge of nutrition so that we

may supplement inadequacies in the natural pollen supply; control of a wide range of bee diseases; easing, if not solution of constant and often serious problems with pesticide poisoning; the efficient use of bees for the pollination of crops, including aspects of plant physiology, bee behavior and bee management; specific studies of the systematics, biology and management of wild bees (non-Apis); the genetics of honey bees and their improvement through breeding, including concern with Africanized bees; and finally, studies of honey, the major product of the apiary.

NRP 20190 Production and Harvesting Equipment and Methods

Equipment and methods are being developed in attempts to solve long-standing and difficult problems in the culture, harvesting, and subsequent farm handling of a variety of horticultural and field crops. Greatest emphasis continues to be on the mechanization of conventional operations which require large inputs of seasonal hand labor, such as fruit and vegetable harvesting. However, emphasis on other important equipment problems, particularly reduction of fossil fuel use and principles of conservation tillage, is increasing. Approximately 45 SY's are involved at 18 locations in 13 States.

Continued progress is reported in improving harvesting equipment for fruits and vegetables, harvesting methods for peanuts and pecans are being improved, a unique system for alternate planting of vegetables is reported, improved systems for cotton culture are gaining acceptance, methods of forage preservation are being improved, and energy-efficient sodium-vapor light sources have demonstrated their usefulness for greenhouse lighting. These diverse developments should indicate opportunities for product improvements to equipment manufacturers and indicate more efficient and energy-effective methods of operation to producers.

SRP Production and Control of Narcotic Plants

This program seeks to affect the production economics of illicit narcotic crops so as to give licit agricultural enterprises a competitive advantage and, secondly, assure that the United States has an adequate and stable supply of raw materials to meet its medical needs for codeine at reasonable cost.

The Department's efforts are designed to be responsive to the perceived needs of the President's program to control drug abuse. International aspects of the program are coordinated through the Department of State, Narcotics Matters; and close liaison is maintained with the Drug Enforcement Administration, Justice Department; the National Institute for Drug Abuse, National Institutes of Health; the Central Intelligence Agency; and the United Nations Narcotics Laboratory, Geneva, Switzerland.

The program is being conducted at 10 locations, involving 5.8 SY's of SEA, FR effort.

SRP Genetic Vulnerability

The mission of this SRP is to emphasize and coordinate the common concern of 21 parent NRP's and 2 other SRP's to reduce the amount of losses of crops caused by pests and environmental stresses. The

commodity programs, the basic plant science programs, the plant germplasm program, and the pest control programs all are intended to lead to the efficient production of high quality, nutritious, safe crops, well adapted to their environments and cultural practices, and so protected from pests and environmental stresses that losses would be held to a minimum. The program is especially designed to minimize the probability of catastrophic losses such as occurred during the southern corn leaf blight epidemic and to enhance the ability to recover quickly from any epidemic that may occur.

No program can reduce the probability of epidemics to zero; however, the approach to lowering the probability, and solving the problem, should one arise, is to have a comprehensive program involving collecting a wide array of genetically diverse germplasm, understanding genetic structure and taxonomy of this material, screening of material for specific useful characters, combining genes from diverse sources into strains more useful to plant breeders, breeding, releasing, and maintaining breeder seed, and producing and distributing high quality planting seed to farmers.

National Research Program 20010

BREEDING AND PRODUCTION - FRUITS, NUTS, AND SPECIALTY CROPS

This National Research Program involves research on breeding and production of fruits, nuts, and specialty crops which will result in increased production efficiency for commercial growers, part-time farmers, and homeowners and increased availability, variety, and quality of fruits and nuts for consumers. Where possible, this research is conducted by multidisciplinary teams comprised of horticulturists, geneticists, physiologists, and pathologists and in association with entomologists, nematologists, agricultural engineers, and marketing specialists. The research is intended to be national or regional in scope and to concentrate on long-range projects not easily initiated or justified by individual State Agricultural Experiment Stations.

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Technological Objective 1.

Develop new and improved varieties of fruits, nuts, and specialty crops that combine improved yield potentials; quality characteristics; better resistance to pests; tolerance to environmental stress; and adaptation for mechanical culture, harvesting, and handling.

Research Locations:

5206	Davis, California
5202	Fresno, California
5212	Indio, California
7606	Orlando, Florida
7706	Byron, Georgia
1108	Beltsville, Maryland
7404	Poplarville, Mississippi
7402	Stoneville, Mississippi
1305	Chatsworth, New Jersey
3307	Wooster, Ohio
5809	Corvallis, Oregon
7708	Clemson, South Carolina
7308	Brownwood, Texas
7202	Weslaco, Texas
5806	Prosser, Washington
5803	Wenatchee, Washington

Selected Examples of Recent Progress:

Embryo culture used in stone fruit breeding program - Fresno, CA.
Over 1200 plum and 2700 peach and nectarine seedlings were successfully grown from very early maturing varieties using embryo culture techniques. Seedlings cannot successfully be grown from these early maturing varieties using the standard methods for seed germination.

In addition, approximately 4500 peach, plum, nectarine, and apricot seedlings were planted. Of the fruiting progenies, 23 peach, 16 nectarine, 4 apricot, and 10 plum seedlings were selected and saved for further evaluation. Four peach, 12 nectarine, 15 plum, and 1 apricot selections are being tested commercially and appear promising as potential varieties. The Castlebrite apricot variety was named and released. The Calita plum variety was jointly named and released with Italy.

Grape breeding reemphasized in California - Fresno, CA. With a commitment to continue grape breeding in California, approximately 4500 grape seedlings from 19 table and raisin grape crosses were planted. Five seedlings were selected from those vines which fruited for the first time and were saved for further evaluation. Seven outstanding selections were grafted and planted in the second test plot. A test planting of a large white seedless table grape selection, which shows potential as a commercial variety, is in its second year at the University of California Kearney Field Station. A test planting to determine the effect of rootstock on the amount of seed trace developed in three seedless varieties is also under test. Evaluation of existing nematode and phylloxera resistant rootstock selections was continued. Callus cultures of three seedless grape varieties have been established.

Disease and salt-tolerant citrus selections under test - Indio, CA. Testing and selection of disease tolerant citrus rootstocks was continued. Twenty Phytophthora and salt-tolerant selections were planted to provide a seed source for further experimental and field work. In 1977, a total of 5200 citrus seedlings were tested for tolerance to Phytophthora root rot. The plants included progeny of 55 salt-tolerant hybrids, 13 new crosses, and 32 Phytophthora tolerant hybrids that fruited for the first time in 1976. Testing of rootstocks under commercial scions was continued in 13 field plots in Kern, Riverside, San Diego, and Ventura counties and on government property. Seed and budwood of promising rootstock types has been supplied to cooperators. This research is cooperative with SEA scientists at Orlando, Florida.

Date germplasm repository established - Indio, CA. The entire collection of named Old World varieties, named males, and domestic varieties was repropagated in June 1977 and becomes the national date germplasm repository. This will serve the current date breeding program and serve as a basis for cooperative date research programs with other date producing countries. Several hundred hybrids in the first to third year of fruiting were evaluated for commercial usefulness. About 30 are being kept for commercial type fruiting in 1978. These include two dry and several semi-dry to soft types potentially useful in the mail order trade. A suitable date to compete with Deglet Noor, the principal California variety, is still being sought. About 350 seedling progeny of 5 date hybrids of the 1971 series were planted to begin genetic studies on inheritance of fruit characters and sex in date palms.

A new genetic source of cold hardiness for citrus - Orlando, FL. Eremocitrus glauca, a cold-hardy, drought-tolerant citrus relative from Australia, has been successfully hybridized with Citrus and F1 hybrids have been shown to be significantly more cold hardy than the Citrus parent. This accomplishment affords the opportunity to introduce cold hardiness through a new genetic source, thus broadening the genetic base of Citrus hybrids. Additionally, Eremocitrus also provides favorable horticultural characteristics not acquired through hybridization with the cold-hardy Poncirus trifoliata and Fortunella. An evaluation for cold hardiness was made on approximately 3000 seedlings following the severe freeze of January 1977 with a minimum temperature of -7°C.

Progress made in citrus rootstock program - Orlando, FL. Twenty rootstock clones were planted in the seedbed and 13 rootstock clones propagated in the nursery for evaluation as potential commercial rootstocks. Forty-one crosses were made to incorporate burrowing nematode resistance, citrus nematode resistance, phytophthora resistance, and tristeza resistance in new, improved rootstock varieties. Evaluated 215 clones for P. parasitica resistance. Preliminary screening of 231 citrus clones for tolerance to root infections was accomplished via inoculations of 10 to 12-month-old seedlings with stem diameters of 3-6 mm. Screened 54 citrus clones, previously screened for tolerance to root infections, for tolerance to stem infections. Screened 20 clones of Microcitrus for tolerance to P. parasitica stem and root infections. Made crosses to incorporate superior cold hardiness characteristics in improved scion and rootstock varieties. Over 2200 seeds were harvested.

Promising orange and grapefruit selections made - Orlando, FL. Fruit production, quality, maturity, and other horticultural characters were determined for 3 advanced hybrids in the breeding program. Fruit of two hybrids was evaluated in postharvest tests and showed a low percentage of fruit decay in storage. The rinds of each had excellent color and ethylene was not needed to stimulate full color. A promising orange hybrid was propagated on several rootstocks for advanced tests as was a promising mandarin hybrid. Nursery trees of 16 varieties of oranges were produced and will be transplanted in the spring of 1978 to determine whether any are superior to commercial varieties. Additional orange and grapefruit hybrids were obtained from pollinations on Mediterranean sweet orange.

Improved peach and nectarine selections made for Southeast - Byron, GA. Two improved peach selections will be released as soon as they can be certified virus-free. Three advanced selections were propagated for distribution to other stations for testing. Approximately 25,000 cross-pollinations were made from 25 parental combinations which resulted in approximately 2300 seedlings. One improved nectarine selection will be released as soon as it can be certified virus-free. Another advanced selection was propagated for distribution to other stations for testing. Approximately 20,000 cross pollinations were made and 1400 seedlings were obtained.

Spur growth characteristic identified in apples - Beltsville, MD.

When apple varieties exhibiting spur growth were hybridized, a large percentage of the F₁ seedlings had spur growth. Now 2000 F₂ seedlings are being evaluated in the nursery and 95% show spur growth. This will allow breeding for spur type apple varieties rather than selecting from spur mutants that are naturally occurring.

Pollen sterility in pears found to be cytoplasmic - Beltsville, MD.

A detailed study of pollen sterility in pears has presented clear evidence that this sterility is cytoplasmic in nature. In some cases, however, it can be overcome by the action of two dominant restorer genes with duplicate recessive epistasis. Efforts are made to eliminate further production of sterile seedlings by not using pollen-sterile parents in the crossing program.

Genetics of resistance to fire blight disease in pears being studied - Beltsville, MD. Computer studies of data from the pear breeding program have shown that low levels of fire blight resistance within Pyrus communis may be successfully combined and increased to a height not observed previously in this species. Different varieties provided some degree of resistance which appeared additive, resulting in several resistant selections. The combination of such additive sources of resistance should result in more resistant pear varieties. Resistance can be destroyed, however, by combining resistant selections with very susceptible varieties carrying the Se gene for susceptibility.

Peaches developed for resistance to bacterial spot disease - Beltsville, MD. Non-bearing peach trees of advanced selections were screened for resistance to bacterial spot disease. One selection, introduced as Cullinan, was noted most resistant of any clone tested. A second selection, introduced as Havis, also was rated more resistant than commercial cultivars. Seedling populations of peaches and apricots were screened and selected seedlings were planted for additional readings of field resistance.

Fruit and tree nut germplasm resources inventory published - Beltsville, MD. A fruit and tree nut germplasm resources inventory containing almost 17,000 items was published. Contacts and correspondence with European breeders indicated the feasibility of expanding the inventory to include germplasm in Europe. A contact person in each European country has been asked to coordinate the data collection for his country and is now adapting the data collection sheet to his language and growing conditions.

Disease resistance emphasized in strawberry breeding program - Beltsville, MD. The strawberry anthracnose resistance program is entering its second year. The inoculation technique needs refining but some resistant hybrids are being isolated in two different testing locales. From 84 controlled strawberry pollinations, 19 seed progenies for anthracnose resistance were sent to Poplarville, Mississippi, for germination and inoculation. The red stele resistance program with strawberries is yielding a higher proportion of resistant seedlings with each passing generation. From 28,641 strawberry seedlings screened in the greenhouse

for resistance to red stele disease, 11,626 (40.59%) were resistant. From the red stele screened strawberries, 2016 seedlings were sent to New Jersey and 4609 everbearer types were planted at Beltsville. Later, 90 everbearers were selected for propagation. Several strawberry varieties adapted to the Eastern United States were screened for resistance to Botrytis fruit rot. Earliglow showed an exceptionally high level of resistance in post-harvest incubation tests. Holiday and Shuksan also showed high levels of resistance but not as high as Earliglow. Parameters giving the most definitive results were incubation at 18-20°C. for 3 days at 90% relative humidity. The Earliglow variety should provide an additional source of germplasm for Botrytis fruit rot resistance breeding.

Blueberry breeding program extends cooperation to other States - Beltsville, MD. The blueberry breeding cooperative program is now operating in 8 States with 2 more States petitioning for seedlings. Another 11,000 seedlings were produced this year to be sent to cooperators. Root rot was not a problem this year in the field where the species hybrids were grown. A diallel 6-parent crossing scheme was being tested with inoculation by 2 strains of the blueberry cane canker fungus in North Carolina. Intercrossing of F₁ species hybrids generally seems to lead to quicker improvement of blueberry hybrids than backcrossing the F₁ to a parent species. The Spartan blueberry was introduced as a productive second early hybrid for Michigan and the Northeast.

Progress made in developing grapes resistant to black rot disease - Beltsville, MD. Nine progenies from wild vines collected in 1965-66 and three from older wild or rootstock varieties were screened for black rot resistance. Resistant seedlings varied from 54 to 100%. Two moderately resistant wild clones showed high levels of powdery mildew in the nursery. Two F₂ progenies showed levels of resistance 63 and 83 percent. First evaluations of F₂ progenies (1976 crosses) show higher than expected percentages of resistant seedlings. Six additional F₂ crosses were made in 1977 for screening.

Differences found in resistance to blueberry anthracnose - Chatsworth, NJ. A total of 29 varieties and four selections were evaluated for resistance to anthracnose, a major disease problem in eastern production areas. Differences in susceptibility were evident with varieties such as Stanley, Burlington, Lateblue, Harding, and Wareham demonstrating resistance whereas Bluetta, Blue-ray, Coville, Berkeley, G-116, and June were very susceptible. No immunity to anthracnose was found but the resistance levels available could be used in the blueberry breeding program to increase disease resistance of future varieties.

Data from pear breeding program computerized - Wooster, OH. Computerization of old fruit and tree data from the SEA pear breeding program has now been completed. Data was extracted from existing records which consisted of up to 20 different field records. It is now possible to retrieve all data for a given seedling or variety

on a single page of computer output. Considerable fruit and tree data has been added to the files which will be used in genetic studies on the inheritance of various fruit and tree characteristics.

Late flowering walnut found - Corvallis, OR. A late-flowering Carpathian walnut seedling has been found and designated as B-4. It is extremely hardy and blooms at the same time as Franquette. This additional germplasm will help in the development of late-blooming walnuts for northern production areas.

Triploid male plants increase hop yields - Corvallis, OR. Detailed data on yield stimulation by 12 triploid male hop genotypes in a commercial Brewer's Gold yard in Oregon have been obtained. Yields increased an average of 30% due to stimulation by triploid pollinators. Seed content was doubled from the 2% for the control to 4% but alpha acid content was not significantly affected. Eight triploid males were identified as suitable Brewer's Gold pollinators in Oregon.

Two new hop selections look promising - Corvallis, OR. USDA 21094 and 21095 have been increased. The 2 lines continued to exhibit superior downy mildew resistance. In early 1977, when adjacent Cluster plots were devastated by the disease, these 2 lines remained free of downy mildew infection. Off-station plots have been established at several locations in the Yakima Valley, Washington; at Grants Pass, Oregon; and near Sloughhouse, California. One test location in the Yakima Valley was on Phytophthora-infested soil. No Phytophthora infection was observed in 1977. The 2 lines have been tested for Prunus ring spot virus and thus far appear to be free of this disease. These 2 selections continue to look very promising.

Yield and quality components of hops studied - Corvallis, OR. Twenty-five random samples were again taken from each of 15 crosses made in 1973 and analyzed for alpha-acids, alpha ratios, lupulin content, and storage stability. Results supported last year's findings that all traits are highly heritable and that good gain in progeny means can be expected by selection of either or both parents. Further gain in all traits can be obtained by selection within progenies.

Hop and mint germplasm repository established - Corvallis, OR. A national germplasm repository has now been established at Corvallis for hops and mint. About 700 mint genotypes already in the collection were maintained and were evaluated for rust and powdery mildew resistance. Several introductions and selections were added to the hop collection. The hop collection now numbers about 200 genetic types.

Dwarf pecan trees found - Brownwood, TX. A dwarf pecan was found by Womack Nursery, De Leon, Texas, and was grafted at Brownwood. It has also been rooted. Three other similar dwarf pecan trees were found near La Grange, Texas, and will be propagated. Another dwarf pecan tree, half the size of adjacent trees, was located at Cordele, Georgia

and propagation wood has been obtained. These dwarf trees will be intercrossed to see if the dwarfing characteristic will be transmitted to seedling progenies.

Seedlings found with resistance to pecan scab disease - Brownwood, TX.

One of the objectives of the SEA pecan breeding program is to develop varieties resistant to pecan scab. Seed from controlled crosses made in 1976, using scab-resistant parental material, were germinated and grown in the greenhouse during 1977. Three hundred forty seedlings resulted from the four parent diallel crosses. These seedlings will be screened for scab resistance over the next three years. A standardized scab rating index was applied to numerous pecan genotypes growing throughout the pecan belt in the 1976 season. From the results of these ratings, 8 scab-resistant genotypes were identified and used as parents in 1977 crosses. Four thousand individual pollinations using the 8 scab-resistant genotypes were made that produced 3000 seeds. These nuts will be planted in a naturally infested scab area at the Southeastern Fruit and Tree Nut Research Station at Byron, Georgia.

Technological Objective 2.

Develop new and improved cultural and management practices for fruits, nuts, and specialty crops that increase yield, minimize production losses, improve quality, and conserve use of natural resources.

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Selected Examples of Recent Progress:

Grape fanleaf disease associated with rootstocks - Davis, CA.

SEA and University of California scientists have established that grape fanleaf disease expression depends on susceptibility of the grape rootstock variety to fanleaf virus. A susceptible fruiting variety grafted to a resistant rootstock is little affected by the disease. Resistance of a rootstock to fanleaf is a characteristic that is independent from

its resistance to nematode vectors. Known sources of resistance among grape species and selections to fanleaf, nematodes, and Phylloxera offer the possibility that a rootstock with multiple resistance to soil diseases and pests can be developed.

Rate of spread of grape leafroll determined - Davis, CA. Leafroll and fanleaf are the most damaging virus diseases of grapes. Although neither kills vines, both reduce yields and quality and are widely distributed. In experiments in fumigated soils, leafroll vines continued to produce less fruit with less sugar at harvest than healthy ones. Leafroll spread a maximum distance of 4.3 M in 23 years in a block of Zinfandel grapes that was set at random with diseased and healthy plants in a commercial vineyard near Lodi, California. Natural spread at this site was less than 17 cm/year. However, an aphid species, identified as Macrosiphon euphorbiae was found on vines at Davis in late November 1977.

Phytophthora species implicated in death of trees in California - Davis, CA. Research showed that six different Phytophthora species are implicated in root and crown rot and death of cherry trees in commercial orchards. P. cryptogea and two unidentified Phytophthora species were shown for the first time to play a significant role in decline and death of cherry trees. P. cambivora, P. dreschleri, and P. megasperma and an unidentified Phytophthora sp. were shown for the first time to be implicated in root and crown rot of apricot, almond, and peach trees. P. citricola and two unidentified Phytophthora species were shown for the first time to be responsible for severe root and crown rot and death of walnut trees in many commercial orchards.

Rootstocks important in control of soil diseases in California orchards - Davis, CA. Texas almond, Lovell peach, Nemaguard and Myro plum seedlings which are common rootstocks of almond, peach, and apricot showed differential resistance to P. cambivora, the causal agent of crown and root rot of stone fruits in California. Artificially inoculated Texas almond was highly susceptible; peach and Nemaguard were moderately resistant; and Myro was highly resistant. Mazzard, Vladimir, and Falstran rootstocks were significantly more resistant than the most commonly used Mahaleb cherry rootstock to P. cambivora and P. megasperma which are known to be causal agents of root and crown rot and decline of cherry trees. Contrary to common assumption by horticulturists, tests revealed that Paradox rootstock is significantly more resistant than Northern Black walnut rootstock to P. citricola, P. cactorum, P. megasperma, and Phytophthora species. However, the Paradox and Northern Black were highly susceptible to P. cinnamomi.

Walnut blackline disease graft transmitted - Davis, CA. The blackline causal agent was graft transmitted from diseased to healthy walnut trees. Eight-year-old healthy walnut orchard trees were inoculated with bark patches from diseased blackline-affected walnut trees. Six of 10 inoculated trees developed symptoms identical to those of naturally blackline-affected walnut trees within 1 year. Research on etiology of blackline has been carried on by various workers since 1924 but this is the first experimental evidence to show that blackline of walnut is a

specific disease caused by an infectious agent. The natural spread of the disease is usually from infected to adjacent healthy trees. Elucidation of the nature and patterns of spread will aid in developing control measures for this disease which is presently considered one of the most important limiting factors for profitable walnut production.

Cherry decline linked to tomato ringspot virus - Davis, CA. Investigation of declining stone fruit orchards revealed a widespread incidence of Prunus stem pitting in California. Prunus stem pitting plays a significant role in cherry decline in California. Results revealed that stem pitting disease of cherry trees is related to the same disease in other stone fruit trees which is caused by certain strains of tomato ringspot virus. The causal agent of Prunus stem pitting can be graft or soil transmitted from diseased to healthy cherry trees. A marked difference was found among cherry cultivars and rootstocks in their tolerance to Prunus stem pitting. Stockton Morello rootstock is highly susceptible, Mahaleb slightly resistant, and certain selections of Mazzard rootstock appeared highly tolerant to Prunus stem pitting. Napoleon cherry cultivar is a symptomless carrier of the stem pitting agent while Bing cultivar is highly susceptible.

Date tissue culture research initiated - Indio, CA. With the employment of Dr. Brent Tisserat, SEA initiated a date tissue culture research program. Dates are not propagated asexually by offshoots and most varieties produce less than one offshoot per year. A rapid method of propagation would have a great impact on world date production. The plant tissue culture facility is now functional and explants have been introduced into culture from lateral buds, apical tips, embryos, flower buds, seeds, and seedling sections. Of the various types of date palm buds cultured, only those with prior leaf differentiation survived and grew in vitro. Adventitious rooting of lateral buds has not yet been noted in these initial studies.

Yellows component of citrus tristeza is also mechanically transmitted - Orlando, FL. Continued research on characterization, transmission, and cross-protection studies on tristeza disease of citrus showed that seedling yellows component of tristeza is also mechanically transmitted and probably not a distinct virus. SEA scientists produced antiserum to sodium dodecyl sulfate (SDS)-degraded citrus tristeza virus coat protein and developed a practical indexing technique based on SDS-immunodiffusion procedures.

Cooperative research conducted on citrus ringspot virus - Orlando, FL. In a cooperative research agreement with Texas A&I on citrus ringspot virus (CRSV), all citrus ringspot cultures tested from Florida, Texas, and California were mechanically transmissible to Chenopodium quinoa. Florida and Texas isolates infected a wide range of citrus and herbaceous plants. The 5 isolates from Texas and Florida which were studied extensively caused similar symptoms but could be distinguished by some minor differences in some indicators. Some isolates of CRSV were not uniformly distributed in infected plants and could be indexed only from self-indicating, symptomatic tissue. CRSV was highly unstable in crude extracts. Purification attempts were unsuccessful.

Citrus mycorrhizal infection studied - Orlando, FL. In research to determine host response of several common rootstocks to mycorrhizal infection, 6 citrus cultivars were each inoculated with Glomus etunicatus, G. mosseae, and G. fasciculatus. One set was fertilized monthly with a 12-6-6 fertilizer and another with 12-0-6. All inoculated rootstocks grown with both fertilizers grew well. Combined growth of all rootstocks was increased 21, 8, and 6-fold by G. etunicatus, G. mosseae, and G. fasciculatus, respectively, with 12-0-6 fertilizer. Combined growth of these rootstocks increased no more than 1.8-fold with these fungi and 12-6-6 fertilizer. Possible commercial application of these growth effects will be studied.

Mineral levels studied in citrus trees affected with blight - Orlando, FL. Five 15-year-old Valencia orange trees on rough lemon rootstocks showing early blight symptoms, together with 5 healthy trees, were lifted out of the ground and samples of the feeder roots, main roots, trunk wood and bark, limb wood, twigs, and leaves were collected and analyzed for 15 elements. Wood and bark of the trunk of blight trees contained more N than that of healthy trees. Blight trees had less P in the limbs and the main roots. With blight, K was lower in the leaves and higher in limbs and Mg higher in the trunk wood. Blight trees had more Na in the leaves and trunk wood but less Na in the main roots. Iron was higher in the trunk wood. Blight trees had higher Mn and Zn levels in the leaves and the twigs. The leaves of blight trees had higher Cu levels than healthy trees. There was an increase of Cl in the leaves and branches with blight and a decrease in Cl in the feeder roots. Blight increased Mo in the branches and the feeder roots but decreased Mo in the main roots. Aluminum levels in the leaves and feeder roots were higher in blight trees. No effect of blight on B was noted. Water-soluble phenolics increased only in the trunk wood of blight trees, not in the main roots and limbs.

Life of citrus leaves studied - Orlando, FL.

Research to determine the life expectancy of citrus leaves in Florida showed that several leaves still remain on the tree after nearly 4 years of study. The average life is much less. Of the leaves produced in 1974, 50% were lost in about 18 months. Leaf losses show a sigmoid curve with the most rapid losses occurring 14 to 20 months after development.

Citrus seedlings show wide response to mineral solutions - Orlando, FL. In continued research on cause of citrus blight, seedlings were treated with different mineral solutions. Rough lemon and sour orange seedlings treated with 10-ppm Mo solution for 6 months were stunted; there was little effect on Carrizo seedlings. Molybdenum treatment raised Zn in the wood of the rough lemon and sour orange seedlings from 3.5 to 5.5 ppm; there was no effect on Carrizo seedlings. In rough lemon seedlings, there was a simultaneous drop in Zn in the feeder roots from 87 ppm in the controls to 41 ppm in the Mo treated roots. Sour orange and Carrizo did not show this effect. Molybdenum treatment caused a lowering of the Cl content of the roots of rough lemon seedlings accompanied by a sharp

increase in Cl in the leaves, even in trees that were not treated with Cl solution. This effect was not observed in sour orange and Carrizo seedlings. Rough lemon seedlings accumulated much higher levels of Mo in the leaves as a result of the Mo treatment (1032 ppm Mo vs 12 ppm for the controls) than sour orange (130 ppm Mo vs 4 ppm) and Carrizo (156 ppm Mo vs 4 ppm). Sodium also accumulated in rough lemon leaves in response to the 10 ppm Mo treatment (3220 ppm vs 307 ppm Na).

Measure of leaf wetness used to reduce pecan spray applications -

Byron, GA. In the mild scab season of 1977, no fungicides were needed on the Stuart cultivar for scab control. On the Schley cultivar, 6 and 9 fungicide applications gave 100% commercial control compared to 92% for 3 applications and 87% for no applications. Applying fungicides after each 100-hour of leaf wetness resulted in 6 applications which also gave 100% commercial control. However, when percent disease-free nuts were considered, the 6 sprays applied with the weather-based spray schedule gave 100% clean nuts compared to 72% for 9 sprays based on the conventional schedule.

Etiology of peach twig canker disease determined - Byron, GA.

Laboratory studies with excised peach twigs supported field observations that bacterial canker resulted from an interaction between the bacterium Pseudomonas syringae and freezing. Dormant peach twigs were incubated in glass tubes after inoculation with sterile water or P. syringae. Twigs from both groups were frozen at -10C or not frozen 7 days later and incubated 10 more days. Typical "sour sap" cankers were found only on twigs inoculated and frozen. This work demonstrated for the first time how the "sour sap" phase of bacterial canker develops in peach and explains why previous inoculation studies without freezing treatments failed to reproduce the disease as it appears in the field.

Mode of infection and spread of gummosis disease determined - Byron, GA.

Gummosis disease symptoms appeared after 10 weeks in peach limbs artificially inoculated with spores of the fungus Boytryosphaeria dothidea. Microscopic studies of inoculated bark showed that the fungus penetrated the bark through lenticels within 2 weeks after inoculation. Fungus spores were observed in rainwater trapped from diseased limbs beginning in mid-March and ending in late December with greatest spore counts in July and August. This research demonstrated that the fungus which causes peach gummosis infects the bark directly without wounds and is therefore a threat to healthy well cared for orchards. Research results show that spores which infect bark are released during rainy periods and preventive fungicidal sprays must be applied during spring and summer. Gummosis has spread from central Georgia to peach areas in Alabama.

Phony peach disease hard to control in Southeast - Byron, GA.

Phony peach disease, at epidemic levels again in the Southeast, can now be studied in terms of relating disease development with the concentration of rickettsial-like bacteria (RLB) in the tissues. RLB counts were generally higher in twigs rather than roots in trees recently developing symptoms of the disease. In trees with symptoms for over a year, root

counts were higher than twig counts. Trees could contain high counts of RLB but not show symptoms for several years. RLB examinations are a means to detect the disease early before insect vectors can spread the disease. Trunk inoculations of Penicillin G reduced the incidence of phony disease from 16% to 6% in an orchard with mild disease incidence and from 75% to 56% in a severely diseased orchard.

Chemical sprays induce early flowering in young apple trees -

Beltsville, MD. Based on the dwarfing effect of chemicals on Delicious and Golden Delicious trees on M 26 and M 106 rootstock, a second experiment was started. In this case, M 111 and seedling rootstocks were used. Combination of ethephon and daminozide sprays produced flowering and fruiting in the first year in the orchard of trees on M 111 but not on seedlings. Ethylene was measured in the wood of apples at the time when flowerbuds developed. One-year-old wood consistently had lower ethylene content than spurs. Treatments inducing flowerbud formation also caused higher ethylene content of the wood.

Ultra-low volume spray applications prove effective in apple orchard -

Beltsville, MD. Continued studies with ultra-low volume fungicide sprays applied with a modified Kinkelder sprayer gave significant disease control. Pressure problems were partially corrected by the use of a small pump geared for low volumes. Formulations containing EL 222, Topsin M, and Captan in combination with glyodin and Agrimycin have effectively controlled the apple scab disease in 4 varieties. In spite of the clogging problems, the spray system appears so promising that a manufacturer of sprayers is building a prototype for evaluation.

Tissue culture of apple and small fruits look promising - Beltsville, MD.

Tissue cultures of several apple varieties were established from actively growing shoot tips. Some of these cultures are growing vigorously and proliferating many additional shoots from lateral buds. Tissue cultures of thornless blackberries were established from actively growing shoot tips. These cultures proliferated many shoots rapidly. The new shoots were rooted in culture jars or in various rooting media under mist in the greenhouse. Establishment of rooted plantlets in soil mixes was very successful under mist. The plants grew very rapidly under greenhouse conditions. Single node stem cuttings of thornless blackberry plants grown in the field or in the greenhouse rooted readily under mist. Peat:perlite (1:1) and peat:sand (1:1) were the best rooting media of the seven tested. Treatment with a rooting hormone had a very slight beneficial effect. Propagation by single node cuttings is commercially feasible and uses a minimal amount of propagating wood for each new plant. Tissue cultures of blueberry shoot tips produced some callus but none of the cultures survived for more than 4 months.

Antibiotic injections help control bacterial disease in peach trees -

Beltsville, MD. Trunk injection of tetracycline into peach trees protected their inoculated leaves from bacterial spot, Xanthomonas pruni, infection for about 50 days after shoot growth started. This was true for injected trees immediately transplanted or those held dormant for about 90 days

before potting. Field grown apricot trees which were trunk injected in September 1975 with oxytetracycline produced 3 times more blossoms than the check trees. Blossoms on the latter were weak while those on the injected trees were strong and vigorous. Fruit production records were not available because of killing frosts.

Improved method for screening strawberries for disease resistance developed - Beltsville, MD. An improved method has been developed for screening young strawberry seedlings for Verticillium wilt resistance in the greenhouse. It combines the use of soil infested with cultures grown on vermiculite and finely chopped plants previously inoculated with the disease organism. Seedling roots are also dipped into a conidial suspension before transplanting to infested soil.

Pilot testing started of decreased use of pesticides in orchards - Beltsville, MD. The pilot testing project is designed to gather information on the lowest level of pesticides which can commercially protect apple trees, the productivity of such orchards, the ecosystem of tests after lowering the pesticide levels, residue levels on the fruit grown in such orchards, the human exposure to pesticides during hand operation in orchards with lowered pesticide levels, and the economic feasibility of such orchards. Orchards will be established at Biglerville, PA, Belchertown, MA, Geneva, NY, and Beltsville, MD. Conclusions reached after testing will help to guide the fruit industry in planting new orchards.

Rabbiteye blueberry production increased in the Gulf South - Poplarville, MS. Recent research has shown that rabbiteye blueberries produce well in the Gulf South, especially with irrigation. Three years after planting, non-irrigated plants produced 2 lbs. of fruit per plant while irrigated plants yielded 10 lbs. per plant. Tifblue, the most productive variety, yielded 36 lbs. per plant 6 years after establishment. Grower interest has greatly increased. From essentially no acreage in 1974, there is evidence that growers will plant from 50 to 200 acres by 1978, most in small acreages.

Water harvested cranberries can be sold to fresh market - Chatsworth, NJ. Water harvested New Jersey cranberries are currently sold principally to processors. SEA scientists have demonstrated that water harvested cranberries may also be sold on the fresh market if properly handled. It was shown that cranberries could be sold on the fresh market if slightly immature, well-colored cranberries were removed from the picking water in 4 hours or less, dried quickly, and stored at 4°C until sold. Fresh market sales for water harvested cranberries would provide additional sales outlets for eastern cranberries.

Non-suckering filbert rootstocks sought - Corvallis, OR.

Suckering is now a major problem in commercial filbert orchards and an SEA objective is to develop non-suckering filbert rootstocks. Several hundred seedlings have been produced from open-pollinated seeds of 14 Corylus species and varieties. These seedlings have been lined out in nursery rows from 36 Corylus species and hybrids to increase the chances

of discovering a non-suckering filbert rootstock. The Ennis variety was successfully topworked to 288 trees of 42 different rootstock candidates. Of these, 168 trees have been placed with cooperating growers for evaluation. Several hundred self-rooted potential rootstocks were produced and are ready for grafting.

ELISA test used to detect small fruit viruses - Corvallis, OR.

Enzyme-linked immunosorbent assay (ELISA) procedures were adapted to the detection of tomato ringspot virus in red raspberry. The method successfully detected 41 ng of virus/ml and could pick up one infected plant among 200 healthy plants during the dormant season. This new method is much more sensitive than conventional methods. The method has also been used with success for tobacco streak virus in raspberry. Black raspberry latent virus isolates were recovered from black raspberries from Pennsylvania and Maryland which differed serologically and in sedimentation properties from tobacco streak virus. Raspberry bushy dwarf virus isolates from red and black raspberry were collected in Oregon and antiserum production against each has begun. The occurrence of tomato ringspot virus in a red raspberry collection was determined by the ELISA method. Many cultivars are infected but show little damage while others are severely damaged. The effects of tobacco streak virus on the yield of boysenberry were measured in ongoing tests.

Strawberry viruses contaminate runner plants - Corvallis, OR.

Since viruses greatly reduce strawberry production, one research objective of the Northwest program is to determine the feasibility of obtaining virus-free strawberry clones by runner plant selection from virus infected mother plants. A very small percentage (0.6%) of such daughter plants from Hood Strawberry infected with crinkle, mottle, and mild yellow edge viruses were found to be free from these viruses under ordinary greenhouse conditions. This is too low a percentage for ordinary virus-free clonal selection but could be a useful preliminary to heat treatment and meristem propagation of refractory material. During this test, leaf grafting methods currently used for strawberry virus detection were found to be only 45% reliable.

Data collected for use of pest-controlling chemicals in filbert orchards - Corvallis, OR. A Federal registration was obtained for the use of Metasystox-R as a trunk application for systemic aphid control on filberts. Since this method of application is objectionable to the grower, efficacy data have been developed for foliage spray application of this insecticide. Nuts have been harvested for residue analysis. Glyphosate has proved effective as an orchard herbicide and a tolerance has been established for its use in filberts. Both a tolerance and an experiment use permit have been obtained for use of Oryzalin in filbert orchards. Napropamide was registered for use in filbert and walnut orchards. It is the only herbicide approved for use immediately following tree planting. Oxadiazone and USB 3153 have been evaluated 2 years and proved wanting in efficacy as compared to other herbicides.

Tree survey of diseased peach orchards complete - Clemson, SC.

An in-depth evaluation of 36,630 trees in 39 peach orchards in Edgefield County, SC, demonstrated in a quantitative way the relationships and importance of management practices, diseases, and the premature elimination of commercial peach orchards. The county orchards are under severe stress from deficient management practices. Approximately 85% of the orchards need erosion and drainage control. A high loss of bearing limbs was caused from fruit overload and tractor damage. The productive potential of the orchards decrease rapidly as the support structure of the trees decays and diseases such as oak root rot, crown gall, and bacterial canker kill productive limbs or entire trees. The orchards soon lose 60% or more of their productive capacity and are then eliminated by the grower. The high variability of soils, management, and disease problems make it difficult to recommend corrective action.

Low trellis hop trials established - Prosser, WA. Low trellis (6') trials were established with 5 different hop varieties planted into 20x10 cm and 30x10 cm plastic tubes. A 1.5 m spacing between rows resulted in an entanglement of vines compared with the standard 2.1 m spacing. Cascade, Comet, Bullion, and Yakima Cluster yields on low trellis were comparable to those on standard trellising. Rivard, an early maturing, low yielding hop yielded 50% more on the low trellis. The modification of a standard grape harvester was used on the mechanical harvest.

Method of drying affects hop quality - Prosser, WA. The research objective was to evaluate the effect of commercial drying and handling procedures on quality of the Cascade variety during storage. Cascade hops dried at 65°C contained less oil than those dried at 55°C. The higher kiln temperature transformed hop acids and reduced bale storage-ability. Cooling time was not critical if hops were at ambient temperature prior to baling. Interior bale temperatures increased only 1-2°C within a 3-day period after baling. Bales placed in -3°C cold storage attained an interior temperature of 0°C within 7 days.

Blister bark of apple graft transmitted - Wenatchee, WA. Blister bark of Red Delicious was shown to be graft-transmissible. The disorder has plagued the Northwest apple industry for years. Blister bark predisposes the trees to injury by winter freezes and limbs girdled by this disease often die. Blister bark was previously reported to be genetic.

Napthaleneacetic acid (NAA) controls apple and pear sprouts - Wenatchee, WA. After 5 years' observation with only 1 application, and after 4 years on pear tree limbs, NAA at various rates (0.5 to 2.0%) and forms (Na salt or ethyl ester) continued to successfully control apple sprouts. Control of apple and pear root suckers is more difficult than trunk or limb suckers and is only effective for 1 or 2 years. However, control is better when root suckers are treated in the tender leaf stage (6-8" long) rather than immediately after pruning. A shield device made with stiff brush bristles mounted

on a portable sprayer was effective in controlling spray drift. When NAA was applied to scaffold limbs, it proved useful in training 3-year-old Delicious trees to a central leader system. NAA is now registered in Oregon and Washington for sucker control.

Mechanism of fruit thinning studied in apple and peach - Wenatchee, WA.

The research objective was to compare new auxin transport inhibitors with TIBA for effectiveness in causing fruit abscission. DPX 1840 and a metabolite were found to be as effective as TIBA in causing apple fruit abscission when applied to fruit stems in bands of lanolin. The two chemicals (TIBA and DPX 1840) are chemically different but both have been demonstrated to inhibit polar auxin transport in other plants. These results strengthen our contention that auxin moving from the fruit to the cluster base is necessary to prevent fruit abscission during the early phase of fruit growth after chemical thinning sprays are applied. TIBA applied as a lanolin band to peach fruit peduncles over a 5-week period did not cause the fruit to drop. The peach fruit set mechanism appears to be different from that of apple which may explain why some chemicals that thin apples do not thin peaches.

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National Research Program 20020

BREEDING AND PRODUCTION - VEGETABLES

This National Research Program involves research in breeding and production of vegetables to develop new and improved genetic and cultural methods that will result in lowering costs of vegetables and potatoes to consumers and increasing efficiency of production of these crops to growers, small acreage farmers, and homeowners. Geneticists, plant pathologists, plant physiologists, and horticulturists (both Federal and State) work in a team approach to evaluate and improve vegetables and vegetable cultural methods.

The research is conducted at 17 locations in 14 States in both Federal and State Stations, where SEA scientists usually work as a team with State scientists.

In 1976 vegetables and potatoes (including dry beans and peas) were harvested from 6.1 M acres with an aggregate value of \$5.4 billion.

NPS Contact: R. E. Coleman (Acting)

PACS Contact: L. L. Jansen

Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of vegetables that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling.

Research Locations:

3611	Palmer, Alaska
5213	Brawley, California
5205	Salinas, California
7702	Tifton, Georgia
1313	Orono, Maine
1108	Beltsville, Maryland
1110	Beltsville, Maryland
3508	East Lansing, Michigan
5809	Corvallis, Oregon
7617	Mayaguez, Puerto Rico
7711	Charleston, South Carolina
7202	Weslaco, Texas
5806	Prosser, Washington
5802	Pullman, Washington
3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Carrots:

Candy Pack a new hybrid carrot released - Madison, WI. This hybrid is more uniform in shape, size and color than Imperator 58 the most popular variety grown in California. Yields are equal and the pack-out is approximately

10 percent higher than Emperor 58. Candy Pack was strongly preferred by a consumer taste-panel and was judged more attractive in color. Total dissolved solids averaged 9.5 percent for Candy Pack, 8.5 percent for Emperor 58 and pro-vitamin A 116 vs. 93 mg/gm fresh weight. These data indicate an increase of approximately 20 percent in vitamin A and 12 percent in sugar.

Cucumbers:

A low level resistance to pickleworm was found in a cucumber accession - Charleston, SC. After screening more than 300 lines and accessions of cucumber, a low level of resistance was found in P.I. 390254. This accession showed the least amount of feeding damage and produced the lowest mean weight of surviving larvae. Such low levels of resistance could lead to an economically important reduction of pickleworm damage in future cultivars.

Seedless cucumber developed - Madison, WI. Hybrid processing cucumber (W744 GP x W1082 HP) is the first seedless type available for outdoor production. It is resistant to five destructive diseases and to cucumber beetle vectors of bacterial wilt. It shows special promise as a home garden variety for use fresh and processed.

Edible Legumes:

Anthracnose resistant lima beans - Beltsville, MD. Anthracnose disease of lima beans is severe in Southeastern production areas. Costs for fungicidal control of anthracnose in recent years has cost some processors as much as \$85 per acre. Several Jackson Wonder and baby green breeding lines derived from crosses of resistant introductions and Jackson Wonder or B2C were developed at BARC. These were found to be highly resistant to anthracnose in field tests in Georgia and Tennessee. The highest yielding, resistant lines with suitable seed characters have been increased for further evaluation.

Green seeded Fordhook lima beans for home gardens - Beltsville, MD. Green-seeded Fordhook lima beans were developed at BARC and are now grown commercially for processing in New Jersey. They are generally not available to home gardeners. Fordhook 169, a green-seeded cultivar developed at BARC, appeared more desirable for home gardens than the popular white-seeded cultivar because of a slower rate of drying of fully developed seeds. This permits a longer period of harvest with several pickings from a single planting. In addition, the green color is more attractive when the beans are prepared and served.

New mechanical damage-resistant dry bean - East Lansing, MI. 'Tuscola', a new Navy (pea) bean resistant to mechanical damage was released jointly by SEA and the Michigan Agricultural Experiment Station. Bred specifically to resist the stress of mechanical handling from harvesting through elevator handling, and processing, the new variety yields somewhat better than the present mechanical damage-susceptible 'Sanilac' variety. 'Tuscola' is also resistant to the alpha and beta strains of anthracnose (Colletotrichum lindemuthianum) and to the type and New York 15 variant strains of bean common mosaic virus.

Two types of resistance to the cowpea curculio discovered in southernpea - Charleston, SC. Two types of resistance in the southernpea (Vigna unguiculata (L.) Walp.) to the cowpea curculio (Chalcodermus aeneus Boheman), the major insect pest of southernpea in the southeastern U.S., have been identified and their inheritance determined. The first, a non-preference factor, reduced the number of attempted feeding and ovipositional punctures per pod, and the second, a pod factor, inhibited penetration through the pod wall by the adult insect. The nonpreference factor and the pod factor were complementary in effect, and together they should provide excellent protection against curculio damage in southernpeas.

Important pea germplasm reslease - Prosser, WA. An edible-podded pea (mammoth melting sugar type with round pods) which is root rot tolerant is being released. This line is an excellent prospect for a home garden type due to a lack of fiber in the pod wall and excellent edible quality.

Two white-flowered canning pea lines are also being released which are immune to Pea Seedborne Mosaic Virus. In addition, these lines are resistant to Fusarium oxysporum f. sp. pisi race 1 and 2 and are tolerant to the pea root rot complex of the Pacific Northwest.

Unique new snap bean germplasm - Prosser, WA. Three new sources of snap bean germplasm were released to public and private bean researchers (ARS-6BP-5, ARS-6BP-6, ARS-5BP-7). These are white seeded, bush snap beans, with resistance to Bean Common Mosaic Virus and the Curly Top Virus which presently limits bean production in the arid regions of the western States. ARS-6BP-6 also carries resistance to some important chlorotic strains of Bean Yellow Mosaic Virus. And ARS-5BP-7 also has a high level of tolerance to heat during bloom, one of the major causes of yield and processed quality losses in snap beans.

Genes responsible for reducing the severity of seedling fungal diseases in peas were identified - Pullman, WA. Genes responsible for reducing the severity of seedling fungal diseases in peas were identified from direct comparisons of near isogenic lines. These genes can be incorporated into disease resistant varieties to provide an important component of an integrated disease control system.

Gene for resistance to Pea Seedborne Mosaic Virus identified - Pullman, WA. A simply inherited gene in lentils was identified which confers resistance to Pea Seedborne Mosaic Virus; a serious disease that drastically affects yields and seed quality. Through the use of this gene, resistant cultivars can be developed and used to control the disease and thus maintain yields and quality of lentil crops. Resistant cultivars represent the most efficient, economical, and reliable method of controlling the disease.

Heat tolerant germplasm for lentils identified - Pullman, WA. Research studies were designed to identify germplasm with heat stress resistance during lentil flower and pod development. Cultivars developed from this germplasm should result in a major improvement in the yield plateau that has been about 1000 lbs/acre since lentils were introduced into the Palouse about 1920.

Lettuce:

High quality, disease-resistant lettuce cultivar Centennial released - Brawley, CA. This small downy mildew race 5-resistant and tipburn-resistant iceberg lettuce has excellent flavor and excellent head shape and internal structure. It matures uniformly. It has been jointly released by the USDA and the University of California specifically for home gardeners. Its resistance to downy mildew will make the use of fungicides unnecessary for the home gardener in areas where downy mildew race 5 occurs. The smoothly folded leaves enable the chef or housewife to remove each leaf whole without disturbing the remaining leaves.

Confirmed effectiveness of big vein resistance in lettuce - Salinas, CA. Big vein resistance, as found in several breeding lines, prevents symptom expression and increases yield. Resistant lines show 15-30 percent of the plants with symptoms compared to 70-95 percent in susceptible lines. Yield under high big vein conditions may be doubled for resistant lines as compared to susceptible lines.

Melons:

Cantaloupe breeding line developed with increased Vitamin C content - Charleston, SC. A green-fleshed cantaloupe breeding line, C-570, has been developed that produced 17 selections with over 40 milligrams of ascorbic acid (Vit. C) per 100 grams of fresh weight. This represents a 20 percent increase over current cultivars, and when developed into a finished cultivar, it would provide consumers with cantaloupes having improved nutritional value.

Reducing Downy Mildew of cantaloupes - Weslaco, TX. It was found that the downy mildew disease of cantaloupes and honeydews requires at least an 8-hour dew period to infect the healthy plants. This disease causes millions of dollars of loss to cantaloupe and honeydew production in the U.S. each year due to direct crop losses and to the expenditures required to maintain preventative fungicidal spray programs against it. Using weather instruments to monitor the dew periods will enable growers to reduce losses to disease as well as reducing the use of fungicides and crop production costs by providing for a lessened and more accurate indicator of when the fungicides need to be applied for proper pest management.

High quality, disease-resistant cantaloupe selected for release - Brawley, CA. Breeding line 17013M combines high quality with resistance to powdery mildew races 1 and 2 and to WMV 1, and with tolerance to WMV 2 and crown blight in Imperial Valley. It is also tolerant to high concentrations of combined minor elements. It culminates 22 generations of breeding and selection with periods of greenhouse testing for specific resistance and hand pollination alternating with periods of mass selection in the field for quality and tolerance to WMV 2 and crown blight. Crossing and selfing with greenhouse testing and hand pollination made the breeding line resistant to powdery mildew races 1 and 2 and WMV 1 and tolerant to concentrated miner elements, but diminished tolerance to WMV 2 and crown blight. Mass selection restored tolerance to WMV 2 and crown blight. Breeding line 17013M should improve quality of harvested muskmelons and reduce losses caused by powdery mildews and viruses in the West.

Mushrooms:

A collection of mushroom germplasm - Beltsville, MD. An inventory of mushroom germplasm accumulated at BARC during the past 8 years indicates that the following number of living mushroom cultures are now in storage: Agaricus - 257, Lentinus - 12, Pleurotus Volvariella - 23, and other genera - 31. The collection includes all species of mushrooms cultivated in the world, and germplasm materials were isolated from both commercial and wild types. This wide range of germplasm will provide the basic material for selection and development of better mushroom varieties.

Virus infection in mushrooms confirmed - Beltsville, MD. Virus infection was confirmed in 104 mushroom farms in the Northeast using a modified gel electrophoresis technique for detection of viral nucleic acids. In this comparative sensitivity study with electron microscopy, there was close agreement between the results of both techniques. Results indicate that the use of gel electrophoresis seems to be a very useful and reliable diagnostic tool for virus infection with the advantages of being rapid, easy to accomplish, and providing data at less cost.

Onions:

Three new sources of onion male sterility - Beltsville, MD. Male sterility was found to occur spontaneously in Allium oschaninii, a wild onion relative from Iran, and was induced when onion chromosomes were transferred by wide hybridization into the cytoplasm of the home-garden topset onion and the Central Asian wild Allium galanthum. Thus, these related species have the potential for supplying new kinds of male-sterile parent germplasm for introduction into the narrowly based, poor yielding male-sterile parent lines now used by the seed industry for producing hybrid onion seed.

Potatoes:

Important potato variety released - Aberdeen, ID. Butte, a new, long russet potato, outyields the popular Russet Burbank variety by 7 percent with 25 percent more U.S. No. 1 tubers. It also has 50 percent more vitamin C and up to 20 percent more protein. It has been jointly released by SEA and the Idaho, Oregon, and Washington Agricultural Experiment Stations for fresh-market and processing use. Butte is resistant to two viruses and to physiological upsets to which Russet Burbank is susceptible.

Ultraviolet irradiation in the sunlight spectrum slows plant virus development - Beltsville, MD. Near ultraviolet irradiation in the solar spectrum UV-B (2800-3200 A) inhibits local lesion formation on Potato Virus S (PVS) inoculated leaves of Chenopodium quinoa plants. This discovery by SEA scientists that near ultraviolet radiation at various intensities can reduce virus infectivity may aid in explaining the erratic behavior often observed in virus infection and transmissibility studies.

Vitamin C content of potatoes can be increased by breeding - Beltsville, MD. Results of a survey of vitamin C content in potato breeding lines and varieties showed that some breeding lines have twice as much vitamin content as others, even after prolonged storage. Varieties also differ in their ability to retain vitamin C in storage. Research is in progress

to select improved types that not only have higher initial contents but also have the ability to retain the high contents through prolonged storage periods.

New natural toxicants in potato hybrids - Beltsville, MD. Previously unknown steroid glycoalkaloids (a class of natural toxicants in Solanaceous vegetable crops) were discovered in hybrids between commercial potatoes and inedible wild relatives. The SEA scientists were able to detect the new natural toxicants using new and sensitive methods of chemical analysis that they developed. The entry of these natural toxicants into new commercial varieties can now be prevented because methods are available to detect their presence.

Inheritance of toxic glycoalkaloids in wild potato - Beltsville, MD. Single major genes were demonstrated to control the inheritance of three glycoalkaloids found in tubers of Solanum chacoense, a wild potato used as a source of pest resistance for potato breeding. This knowledge will contribute to more efficient use of resistance germplasm from wild sources if, presumably, the genes for the undesirable glycoalkaloids can be manipulated independently of and excluded from the desirable traits being introduced into new potato cultivars.

Performance of the new variety Atlantic - Beltsville, MD. The widely adapted, pest resistant, high quality variety Atlantic, jointly released with the Florida, Virginia, New Jersey, and Maine Agricultural Experiment Stations, was in significant commercial production in 1977. Reports from 16 eastern, southern, and midwestern States indicated a 5-25 percent increase in yield per acre to producers and a 15-20 percent increase in product recovery to processors over other varieties grown. Atlantic tubers contain the highest total solid content of any variety grown in the U.S.

A potato variety of superior chipping quality to be released - Beltsville, MD. B6987-29, a high quality, multiple pest resistant, including resistance to the golden nematode, widely adapted clone with round white tubers and especially suited for chip processing, will be released jointly with the Florida, Virginia, New Jersey, and Maine Agricultural Experiment Stations as the variety Belchip. Belchip slightly exceeds the newly released variety Atlantic in yield, has slightly less total solids, but produces a lighter colored chip than Atlantic.

First Russet potato variety adapted to northeastern U.S. to be released - Beltsville, MD. Clone B7147-8, a high quality, multiple disease resistant, medium-late maturing russet clone with highly attractive long tubers and adapted to the northeastern U.S. and Florida, will be released jointly with the Florida and Maine Agricultural Experiment Stations as the variety BelRus. BelRus is 5 percent higher in total solids and produces 10 percent greater yield per acre of more attractively shaped tubers than the very late Russet Burbank variety. Quality of BelRus for baking and processed products is equal to or exceeds that of Russet Burbank.

Improved disease-resistant potatoes - Prosser, WA. Potato clones have been developed which offer significant improvements in yield, quality, grade, and resistance to pests and to foliage, soilborne and physiological diseases. These improvements are critically needed to reduce the high costs of producing, processing, and packing potatoes. They could reduce

the threat of bankruptcy that many potato producers would face as a result of disease epidemics, poor yields or inferior quality. The reduced need for dangerous pesticides would help protect our environment and save the energy needed to manufacture and apply such pesticides. Our high yielding, high protein lines have great importance in a world where protein is a limiting factor in human health. Our new method of direct seeding true potato seed into the field also has worldwide significance as a means of producing disease-free potatoes without using certified tubers that are either not available or very expensive in many under-developed countries in the world.

Reduction in losses to net necrosis - Prosser, WA. Leafroll virus-infected potato tubers frequently develop net necrosis (an internal network of black threads) in storage. Affected tubers cannot be processed and sorting them from healthy tubers is expensive. If heavily leafroll-infected fields could be identified prior to harvest and processed immediately rather than stored, much of the loss to net necrosis could be prevented. A rapid, reliable, and inexpensive test for this purpose has been developed which involves staining leaflets with iodine. Its application in the northwest could save \$20 to \$25 million yearly.

Meristem culture procedures adapted for use with species and foreign cultivars in the IR-1 tuber-bearing Solanum collection - Madison, WI. About 400 accessions of both wild and cultivated species and foreign cultivars are being maintained clonally at present by the IR-1 potato collection. Because of their clonal status they are targets for various potato viruses which threaten their future usefulness and may even result in their loss. Meristem culture has been a useful tool in freeing clonal material of virus. Now suitable media have been identified or devised allowing meristemming to be successfully applied to a broad range of foreign cultivars and species of potato. The successful application of this technique will permit the maintenance of virus free clonal germplasm and insure its availability to future generations.

Sweet Potatoes:

Sweet potato developed that has resistance to all known biotypes of the southern root-knot nematode - Charleston, SC. The sweet potato breeding line, W-51, has resistance to all biotypes of the southern root-knot nematode; and, most importantly, to the recently discovered, highly virulent race of the nematode. It is presently the only known source of resistance to the new race. In addition, W-51 is highly resistant to the tropical root-knot nematode, the northern root-knot nematode, and to Fusarium wilt. In field tests it performed about like cultivars Centennial and Jewel. W-51 flowers early and profusely, and it sets sufficient seed for breeding purposes.

Tomatoes:

Two potential tomato varieties for processing - Beltsville, MD. Two advanced tomato breeding lines were selected as candidates for release following one additional year of testing by grower-cooperators.

Anthracnose resistance in tomato confirmed - Beltsville, MD. Anthracnose-resistant breeding lines developed at Beltsville were confirmed resistant to two species of the causal fungus at Purdue.

A new tomato variety released - Charleston, SC. A new tomato variety named 'Patriot' was developed for use in home gardens and other fresh-market production where the southern root-knot nematode is a problem. Patriot is resistant to root-knot, Fusarium wilt (race 1), gray leaf spot and tolerant to early blight. It is comparable to Homestead in appearance.

New Curly Top-resistant tomatoes for home gardens and industry - Prosser, WA. Tomato lines have been developed that make processing, market garden and home garden tomato production possible throughout the Intermountain West with little loss from curly top. Thousands of growers and gardeners who had learned to live with losses from this disease now can produce a full crop. Vast areas from the Mexican to the Canadian border that are well adapted to tomato production except for curly top disease could now be used for commercial production.

Complete resistance to Curly Top of tomatoes - Prosser, WA. The transfer of complete resistance to curly top virus from wild relatives of tomato into hybrids of crosses between the wild relatives and the cultivated tomato could very well be a major breakthrough in agricultural science. After 60 years of searching, a permanent, inexpensive, and nonpolluting solution to the curly top disease of tomato seems assured. The resistance is of a simple type and should be easily transferable to any type of tomato. It should open the vast Intermountain West to tomato production where it was once closed by curly top. It should also eliminate the large annual losses to curly top sustained in great tomato fields of California. Application of insecticides to thousands of acres in the foot-hill breeding grounds of the vector of curly top in California should no longer be necessary.

Technological Objective 2.

New and improved cultural and management practices that increase vegetable yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

Research Locations:

3611	Palmer, Alaska
5213	Brawley, California
5205	Salinas, California
7702	Tifton, Georgia
1313	Orono, Maine
1108	Beltsville, Maryland
3508	East Lansing, Michigan
5809	Corvallis, Oregon
5806	Prosser, Washington

Selected Examples of Recent Progress:

Edible Legumes:

Standardized system to classify legume viruses - Corvallis, OR. In cooperative work by eight scientists from five countries, reactions induced by 38 documented legume viruses on 23 standardized plant hosts were determined. From this information, a key was formulated for tentative diagnosis of the mechanically transmissible legume viruses of northern hemisphere temperate climates. We believe this represents the first international effort to comprehensively standardize induced responses to 'type cultures' of viruses by hosts that consisted of uniform germplasm. Reference germplasm for the 23 plant hosts is stored at the National Seed Storage Laboratory, Fort Collins, CO.

Melons:

Protecting muskmelons against aphid-borne viruses - Brawley, CA. Experiments demonstrated that a protection crop, such as wheat, delays infections caused by aphid stylet-borne viruses and improves marketable yields, melon appearance and soluble solids. Additional research is needed to learn to grow muskmelons with a protection crop without delaying maturity or depressing total yield. The findings added a new type of virus control that can be used in a pest management program to improve production efficiency and product quality.

Potatoes:

Effects of systemic insecticides on potatoes - Orono, ME. By establishing the possible detrimental effects systemic insecticides might induce on potato plants, growers may be more selective in their insecticide programs. The tremendous increase in Rhizoctonia on potatoes in the Northeast might be related to the increased use of these systemic insecticides in the last 3 years.

Tomatoes:

Improved tomato transplant performance by Ethephon treatment - Tifton, GA. Ethephon spraying (300 ppm in 935 l water/ha) of southern field-grown tomato transplants under favorable environmental conditions and prior to first flower opening increased root proliferation, increased plant dry matter, eliminated early fruit set, increased plant vigor after northern transplanting, reduced early fruit yield and increased single-harvest fruit yield. Transplant treatment increased fruit yields in single harvest by 0-30 percent and should average over 10 percent. This was a cooperative research effort between SEA-USDA, several northern Universities and tomato processors.

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National Research Program 20030

BREEDING AND PRODUCTION - FLORIST and NURSERY CROPS

This National Research Program deals with multidisciplinary research to develop new technology for improving productivity and increasing efficiency in the production of florist and nursery crops to enhance urban and rural environments. This need for new knowledge makes it essential to provide research results on selecting, improving, protecting, maintaining, and cultivating plants for urban and rural home, landscape, and special purpose plantings such as parks, roadside, and shopping centers.

Florist and nursery crops fulfill a social as well as an agricultural need. They affect human feelings and attitudes and greatly enhance human surroundings. Green plants and flowering plants are being used increasingly in and around homes, offices, and public buildings. The retail value of foliage and pot plants is estimated at over \$1 billion annually. The growth in the bedding plant industry in the last few years is probably unexcelled by any other agricultural commodity.

The USDA research program in Florist and Nursery Crop Production Practices is located at three primary centers: Washington, D. C.- Beltsville, Maryland; Delaware, Ohio; and Corvallis, Oregon. These programs are located at Federal and State research stations where SEA scientists work closely with State scientists and closely complement research activities in State programs.

NPS Contact: R. E. Coleman (Acting)

PACS Contact: L. L. Jansen

Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of florist and nursery crops that combine improved and favored quality characters, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling.

Research Locations:

1211	Washington, D. C.
1108	Beltsville, Maryland
3605	Mandan, North Dakota
3306	Delaware, Ohio

Selected Examples of Recent Progress:

Breeding lines and germplasm developed - National Arboretum, Washington, D.C. Breeding lines and germplasm have been developed in a large number of species. A few examples are: pine hybrids between eastern white and Balkan Pine, white birches resistant to bronze birch borers, Cotoneasters resistant to fireblight, a compact, dense flowering viburnum, fragrant Camellias, flowering crab apples with dark red fruit, a new improved birch seed orchard.

Pyracantha cultivars with multiple disease resistance - National Arboretum, Washington, D. C. Multiple disease resistance to scab and fireblight has been achieved with the introduction of two Pyracantha cultivars, 'Shawnee' and 'Mohave', and two additional selections are to be introduced in 1978. In 6 years since its introduction 'Mohave' has become a leading variety in both the United States and abroad and was listed in 45 catalogues. The interspecific hybridization of Lagerstroemia indica and L. fauriei has produced an array of mildew resistant tree and shrub type selections which combine superior flower and trunk bark color characteristics. Two of the F_1 selections will be introduced in 1978. The production of triploidy in Hibiscus syriacus has produced plants with prolific flowering throughout the summer and no seed production. One cultivar, H. syriacus 'Diana', has been introduced and additional flower color selections are being increased for future introduction.

New shade tree for restricted areas - National Arboretum, Washington, D.C. Pyrus calleryana 'Whitehouse' displays most of the desirable phenotypic characteristics of 'Bradford' and like 'Bradford' is resistant to fireblight. Its narrow columnar crown makes it ideal for small suburban yards and other space limited areas.

Introduction of 3 new cultivars in Painted Impatiens series - Beltsville, MD. Impatiens, brought into the U.S. in 1970, have been used in a breeding program to introduce new plant germplasm for the garden. The original forms were tall and infrequent in flowering. Three new cultivars in the Painted Impatiens series, 'Pink Cascade', 'Pink Lady', and 'Pee Gee', were introduced in 1977. All had variegated foliage, large and intensely colored flowers, and everblooming habit.

Chimeral nature of poinsettia varieties - Beltsville, MD. Investigation of many commercial poinsettia cultivars has shown many to be chimeral. Two pink cultivars gave all red "progeny" from induced adventitious buds. The cultivar 'Annette Hegge Supreme' produced two kinds of adventitious "progeny" - one darker, and another paler. Several different arrangements of both diploid and tetraploid tissue were found in some of the "tetraploid" cultivars. All the chimeral forms are unstable to some degree, and undesirable mixtures do occur in commercial crops. Propagation procedures which will eliminate or minimize these mixtures can be devised by the commercial propagator based upon our results. A detailed analysis of the pigment system in poinsettia cultivars is being conducted. The purpose is to evaluate these procedures as possible means of distinguishing between closely related cultivars and develop criteria which could be used to document plant patent applications.

Conservation windbreaks effect on crop production - Mandan, ND. Federal research scientists have determined that field windbreaks, with proper soil and water management, do increase crop productivity. When irrigated wheat was protected with a windbreak, yields were increased 22 percent over the crop not protected by a windbreak. With proper windbreak management to trap snow over the crop area, dryland wheat yield increases were nearly as great as those for irrigated wheat. Since there are approximately 48,000 miles of field windbreaks in North Dakota, and many more thousands of miles throughout the Great Plains, these studies indicate that windbreaks on the Great Plains may improve the efficiency of small grain production while simultaneously protecting soils from wind erosion.

Relative salt tolerance of urban tree species - Delaware, OH. Seedlings of seven commonly planted tree species subjected to highway deicing salt in a water culture system showed wide variation in leaf symptoms. Symptoms included marginal browning of leaves, followed by premature leaf drop. Species ranked from those with least to those with most phytotoxicity are: Japanese pagoda tree (Sophora japonica), white pine (Pinus strobus), honeylocust (Gleditsia triacanthos), ginkgo (Ginkgo biloba), sycamore (Platanus occidentalis), pin oak (Quercus palustris), and flowering dogwood (Cornus florida).

Identification of maple cultivars by scanning electron microscopy - Delaware, OH. Red maple cultivars which could not be distinguished by conventional taxonomic techniques were identified by scanning electron microscopy on the basis of micromorphological differences. This research represents the first published data revealing such differences between vegetatively propagated plants. The method has the potential of becoming a quick, inexpensive, and reliable test to separate cultivars of the same species and would benefit the entire horticultural industry including the segment concerned with plant patents.

Technological Objective 2.

New and improved cultural and management practices that increase florist and nursery crops yield, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

Research Locations:

7702	Tifton, Georgia
1108	Beltsville, Maryland
3306	Delaware, Ohio
5809	Corvallis, Oregon
5804	Puyallup, Washington

Selected Examples of Recent Progress:

Root and crown rots of juniper and azaleas - Tifton, GA. Species of Phytophthora and Pythium were identified as the causal organism for root and crown rots of shore juniper, Blue Rug juniper and several azalea cultivars. Several fungicides used either as a soil mix or a drench gave effective control. This information will be used in obtaining registration for the use of these compounds for nursery control.

Equal energy - equal growth for plants - Beltsville, MD. Extensive tests, conducted with 34 kinds of plants, have demonstrated that any visible light source can be used to boost the growth of plants when compared on equal watts per meter square. This means that supplemental lighting in greenhouses, nurseries, malls, and homes is strictly energy dependent in the visible region and may be supplied by broad (fluorescent and high pressure sodium) and narrow band (low pressure sodium) lamps. We can achieve savings of electrical cost up to 60 percent using this information.

Stable flavonol from morning glory for use as a food colorant - Beltsville, MD. A new flavonol was isolated and identified from 'Heavenly Blue' morning glory flowers and is solely responsible for the color of the flowers. It is stable in water solution and appears to be an excellent candidate to replace some of the delisted food additive dyes. By adjusting the acidity, colors were obtained similar to cherry, strawberry, raspberry and grape. A public service patent for its use as a food colorant has been filed.

Growth regulators control tree regrowth along powerlines - Delaware, OH. Water solutions of commercial formulations of maleic hydrazide and dikegulac were pressure-injected into the trunks of topped silver maple, red oak, shamel ash, eucalyptus and American sycamore to evaluate their potential to reduce sprout regrowth. Regrowth was significantly reduced by at least one concentration of each chemical for all species tested. Healing of injection wounds occurred independently of chemical treatment and just as rapidly with or without the application of wound dressing.

Improved techniques for Dutch Elm Disease (DED) control - Delaware, OH. To develop better procedures to apply systemic pesticides to elms for DED control. Present procedures result in damage to the tree, are too expensive, and result after in poor distribution of the fungicides. However, because of the desperate need these procedures are being widely used. Our studies are aimed at finding less expensive and more effective means of applying systemic fungicides to elm trees. We developed a portable syringe injector and procedure which allows 2 men to inject concentrated fungicides into a large tree in 10 minutes (other procedures require an hour). Indications are that this procedure results in better distribution of the fungicides than other methods.

Plant lysosomes may have role in plant disease control. Delaware, OH. To understand the role of lysosomes in host-parasite interactions and cellular defense. Lysosomes have only recently been recognized as components of plant cells. The object of these investigations is to elucidate the role of lysosomes in plant diseases with the eventual hope of manipulating these organelles to control plant diseases. Through the study of a highly-balanced host-parasite interaction (Elsinoe on Desmodium) we demonstrated that a lysosomal system apparently operates in the packaging and movement of excretions by the pathogen into the host. The packaging and transport of exogenous materials by the host and their deposition in the host vacuole may be a cellular defense mechanism. The host vacuole is capable of digesting foreign materials without disrupting the rest of the cell. Acridine orange was found to be taken up by fungal spores and concentrated in their vacuoles. The vital dye floresces reel-orange with UV light in a similar manner to animal lysosomes. It was further demonstrated that acid phosphotase (a lysosomal marker) is also concentrated in fungal vacuoles. The conclusion is that acridine orange can be used as a lysosomal marker in fungal cells as it is in animals. Fungal vacuoles were found to sequester and digest glyrogen and lipids. This appears to be a normal means whereby these storage substances are mobilized in fungal cells.

Rose powdery mildew control - Corvallis, OR. Powdery mildew is the most costly and troublesome disease of cut rose production and is presently only partially controlled by repeated and consistent fungicidal sprays.

The discovery of the total protection and even eradication of the disease in a commercial greenhouse by volatilizing fungicides applied to a hot pan or heating pipes offers real hope for control in the future. This system has been effective with already-registered materials applied in small amounts in a greenhouse closed up for 4 hours during the night, making application safe, economical, and remarkably less polluting, yet giving complete coverage and control. The volatilization principle has application to many other greenhouse foliage disease situations.

Mycorrhizal fungi enhance rooting - Corvallis, OR. The addition of mycorrhizal fungal inoculum to the rooting medium greatly enhanced rooting of Arctostaphylos and other woody plant cuttings. While the mechanism of this phenomenon is still under investigation, the results to date are of practical significance to the nursery industry, especially with difficult-to-root species.

Stress ethylene - Corvallis, OR. Ethylene is evolved by plants subjected to environmental stresses including air pollution and fungal pathogens, often before visible signs of the disease, other stress damage, or a growth reduction. In the case of disease, ethylene is evolved within hours after penetration of the fungal pathogen. The pathogen, Cylindrocladium, is able to produce ethylene in vitro only in the presence of methionine, a normal constituent of plant tissue. These results offer some hope of detecting latent infections or stresses in time to take corrective action.

Weevil feeding preference in Rhododendron - Puyallup, WA. The problem of weevil feeding damage on rhododendrons is of major significance to the nursery industry, but also to the multitude of home gardeners that experience great loss due to these pests. Weevils feed on certain Rhododendron species and not on others. For example, R. thompsonii is susceptible while R. williamsianum is resistant to weevil feeding. Results have indicated some morphological differences, but also that susceptible species form an extractible attractant which, if added to resistant leaves or cellulose acetate filter discs, makes them palatable to feeding weevils. This knowledge is useful and supportive of breeding programs aimed at developing weevil feeding resistance, since the trait may be linked to the inherited trait of stimulant production.

Technological Objective 3.

To enhance environmental quality by reducing pollution and improving man's surroundings.

Research locations:

1108 Beltsville, Maryland
3306 Delaware, Ohio

Selected Examples of Recent Progress:

Air pollution diagnosis and protection - Beltsville, MD. A growth modifying response has been found with the use of N- 2-(2-oxo-1-imidazolidinyl) ethyl -N-phenylurea (EDU). It prevents the damaging effects of free radicals which are formed in the membranes of cells in response to exposure

of the plants to fumigations with ozone (complete protection) and sulfur dioxide (partial protection). The chemical does not alter any of the visual aspects of the plants. Its sole activity is to afford immediate air pollution protection and will serve as a guide to assess the impact of air pollution on vegetation.

Identification of O₃ + SO₂ damage by scanning electron microscopy - Delaware, OH. Scanning electron microscopy was used to detect inter-cellular injury to plants induced by ozone and sulfur dioxide. This technique could be used by plant scientists to diagnose air pollution injury to plants and to distinguish it from other forms of environmental stress.

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National Research Program 20040

BREEDING AND PRODUCTION - CORN, SORGHUM and MILLETS

This program is a part of the USDA-FR Mission on Agricultural Production Efficiency with the goal of producing new knowledge and improved germplasm to increase productivity. These important feed grains are of major significance for both domestic and export utilization as food, feed and industrial uses. To a lesser degree the program contributes to Mission 3 - Agricultural Marketing and Distribution and Mission 10 - Foreign Agricultural Development. The program is organized under two technological objectives.

NPS Contact: P. H. Harvey

PACS Contact: L. L. Jansen

Technological Objective 1.

New and improved genetic populations, breeding lines, and hybrids of corn, sorghum and millets that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting, and handling. Develop basic genetic, cytogenetic, physiologic, and biochemical knowledge necessary to accomplish these goals.

Research Locations:

7602	Gainesville, Florida
7702	Tifton, Georgia
3420	Manhattan, Kansas
3311	Urbana, Illinois
3302	West Lafayette, Indiana
3408	Ames, Iowa
1108	Beltsville, Maryland
7502	Mississippi State, Mississippi
3402	Columbia, Missouri
3416	Lincoln, Nebraska
7802	Raleigh, North Carolina
3307	Wooster, Ohio
3608	Brookings, South Dakota
7302	College Station, Texas

Selected Examples of Recent Progress:

Corn:

Efforts to reduce genetic vulnerability - Tifton, GA, Mississippi State, MS, Columbia, MO, Raleigh, NC and College Station, TX. Genetic vulnerability continues to be of concern in this major feed crop. Cooperative work in several States is directed at screening of exotic germplasm for pest resistance. Two hundred exotic races were screened for insect and disease resistance and for general yield and agronomic characteristics.

Preliminary observations were made on an additional 249 exotic race collections at one location. Those exotic races which have indicated good agronomic characteristics and resistance to one or more pests, are now being combined in crosses for study in the development of germplasm with combined resistance and agronomic acceptability. A data base system has been developed for cataloguing, retrieving, and updating exotic germplasm data.

Sixty-five exotic corn populations with downy mildew resistance are being maintained for future research work. Six cytoplasms are under study in 7 inbred line backgrounds. Exotic base populations were evaluated for yield and agronomic characters and maturity and leaf diseases. Selections show good leaf blight resistance but only mediocre yield at this stage.

Developing breeding systems - Tifton, GA, Ames, IA, Columbia, MO, and Raleigh, NC. Research effort to utilize different breeding systems in improving corn germplasm populations is underway at a number of locations. A sequential culling program with 10 characters being selected at sequential levels for improvement of populations with multiple pest resistance and agronomic traits is underway with mass selection. Studies on the stalk quality as it relates to standability are continuing in several locations. The resistance to lodging is correlated with the crushing strength of sectors of the stalk. These vary from roughly 400 kgs. to 1200 kgs. per 2-inch section. Crushing strength, stalk section weight, and rind thickness are all being used in the selection program.

Maturity strains are being studied using a diallel design and observing the pollen-shedding date. These 9 strains cover a wide range of maturity from extremely early to extremely late. Reciprocal full-sib selection is being used in population improvement for general agronomic and yield characteristics and for the development of new inbred lines from each of the cycles of recurrent selection. Mass selection is being used for such characteristics as the role of ear length on yield and agronomic traits, improvement of grain quality in special mutant types such as, shrunken-2 and opaque-2.

Empirical and simulated studies indicate complete dominance of favorable alleles and best explain the results of reciprocal recurrent selection for yield in two populations. Recurrent selection, using S_1 and S_2 progeny, to increase gene frequency of favorable genes governing grain yield, protein content, lysine content, and grain quality in both normal and opaque-2 synthetics is continuing.

These breeding schemes are contributing germplasm for commercial use. Ten releases have been made during the past year. Five are inbred lines designed to be used as parents of commercial hybrids and show improvement in general agronomic characteristics and B84 has resistance to first brood European corn borer and good stalk strength. The other four lines are improved types closely related to the popular Mol7. The other five releases are germplasm releases which contribute either insect or disease resistance or high yield factors.

Selection for special morphological characteristics - Raleigh, NC and Brookings, SD. Selection for brachytic-type dwarf lines has been conducted at two locations. At one location, the selection is for full season (relatively late maturing) dwarf strains. The other location has been selecting for dwarf strains which perform well in crosses and are resistant to root lodging, stalk breakage, and low shelling percentage as compared to their normal height counterparts. These selection programs have been making improvements in the brachytic-type dwarfs in general agronomic characteristics.

Empirical observations have indicated that corn lines with vigorous strong root systems are more tolerant to the occurrence of the western corn root-worm damage. Recurrent selection for root pulling resistance has been conducted in three synthetic varieties. Thirty-three lines and their test cross hybrids have been evaluated for root pulling resistance. Large differences were found among lines and these have been correlated with their test cross hybrids and the results indicate that the differences in root pulling resistance is highly transmitted to the hybrids.

Biochemical and quantitative genetic research - Urbana, IL, Ames, IA, Columbia, MO, and Raleigh, NC. Studies of genetic control of isozyme variants now indicate about 20 loci involved in the variation detected using starch gel electrophoresis. These isozyme traits are being utilized to determine relationships among racial collections of corn and to determine utilization of isozymes as selection units for improving grain quality. Only a few of the isozyme loci have been localized on chromosomes. At present one is associated with chromosome 9, 6 and 10, respectively. These have been located by the use of primary trisomics.

Some 254 inbred lines have been assayed for their enzyme characteristics to identify rare alleles, compare U.S. with Latin American races, and to verify the purity of inbred line seed stocks. The verification of inbred line purity is now a costly field operation. This laboratory technique might be much quicker and less expensive.

Electrophoretic systems are being expanded and eventually the amino acid composition of the individual proteins can be determined after they have been separated and isolated. With this information it may be possible to select agronomically desirable opaque-2 hybrids (and other mutants) which replace zein with protein bearing a higher lysine content under conditions producing high yields of total dry matter and protein.

Phenolic compounds were found to inhibit growth of the fungus Diplodia zeae. Crude fractions of resistant and susceptible plant material added to the media had no effect on growth of the fungus organism. In mature kernels of an inbred line, the germ contained 82 percent of the total lipids and the endosperm 17 percent. The endosperm was high in tri-unsaturated linolenic acid and free fatty acids made up 31 percent of the endosperm lipids. Whereas only .5 percent of the germ lipids were free fatty acids. A fairly accurate prediction of fatty acid composition of the hybrid can be made by analyzing the fatty acids of the parents and assuming an equal contribution from each parent.

Cytogenetic investigations - Columbia, MO. New considerations of mechanisms of gene regulation and of exchange of macromolecular components between cells are required to explain complementary interactions involving dominant inhibitor genes and the bronze Bz gene.

Determined that nuclear and cytoplasmic factors interact to affect frequencies and patterns of sectors induced by iojap (ij) and chloroplast mutator (cm) genes. Several chromosome segments have been identified that may influence the process by which dosage affects crossing over.

Comparisons of frequency of nondisjunction and preferential fertilization of two inbred backgrounds showed L289 background to have 2 1/2 times as great a frequency of deficient endosperm as the background by ACR-nj W23. These studies were conducted using B-A translocations. 16 B-A translocations were on the uniform L289 background and 13 on ACR-nj W23 background. Study with teosinte cytoplasm from Honduras incorporated into corn belt maize appears to affect seed size.

Grain quality investigations - Tifton, GA, Manhattan, KS, Ames, IA, and Beltsville, MD. Genetic studies are underway to locate the chromosome positions of genes controlling the biochemical quality of grain fatty acids - palmitic, oleic, and linoleic acids. Studies continue on the selection in populations containing the opaque-2, sugary-2 and other mutants for improved protein quality and general grain acceptability. A large number of samples are analyzed for their lysine content in relationship to the general quality of the grain in the selection program. Using various grain endosperm types including the mutants, several different methods of analysis have been studied. The infrared reflectance, biuret, and dye-binding methods were evaluated as procedures for estimating or screening of protein quality (lysine and/or tryptophan contents). The usefulness of the methods in estimation of protein and quality in maize was evaluated.

Advances in host-plant resistance to pests - Tifton, GA, W. Lafayette, IN, Mississippi State, MS, Columbia, MO, Wooster, OH, and College Station, TX. Sixty-five exotic corn cultivars have been screened and shown to be resistant to downy mildew. These are being reproduced to develop a downy mildew resistant composite. Greenhouse and field screening of corn lines have shown that all lines are equally susceptible to downy mildew at the time of germination. Those that carry field resistance develop resistance earlier than the field susceptible lines.

On the basis of 1 year's data, it appears that there are genetic differences for aflatoxin production (caused by Aspergillus flavus) potential among certain South Carolina experimental single crosses and flavonoid genotypes. Differences also were significant among commercial hybrids for levels of sporulation on agar in which kernel material has been incorporated.

Interrelations of plant, insect, fungus, and environment to Aspergillus flavus infection and aflatoxin production showed no difference among hybrids in incidence of aflatoxin positive samples among hybrids and planting dates. Both European corn borer and the corn earworm increased the

level of aflatoxin over controls in samples that had been artificially infested. Corn earworm and fall armyworm larvae acted as carriers of A. flavus although not infested by them but are adversely affected by the aflatoxin production by the fungus.

Breeding populations with improved tolerance to maize dwarf mosaic virus and to maize chlorotic dwarf virus have been developed. S₁ progeny from these populations have produced satisfactory hybrids in combination with Mol7 for grain yield. Previous studies to determine the genetics of resistance to 5 strains of maize dwarf mosaic virus, following mechanical inoculation, using chromosomal translocations, indicated that Pa405 carried a single dominant gene or closely linked genes for resistance to MDMV strains A, B, D, E and F. Tests involving reciprocal translocations indicated associations with both arms of chromosome 6.

Maize inbreds infected with anthracnose under field conditions showed the greatest amount of stalk rot when inoculated 4 to 5 weeks after anthesis but the mineral, nitrogen and protein contents were affected the least with this time of inoculation. A few lines were resistant to the anthracnose stalk rot and also their metabolism was not altered.

Inbred lines adaptable to the Corn Belt with multiple resistance to northern corn leaf blight, anthracnose, and downy mildew have been developed. Some of these lines are nearing readiness for release.

Fusarium moniliforme is found in corn tissue throughout the growth and development of the corn plant. The percentage of internally infected kernels used as seed does not seem to be correlated with the amount of fungus in the young plant. The percentage of kernels on the ear with internally infected kernels increased from mid-silk to harvest.

Over one-third of the commercial corn hybrids that were tested had a rather high level of resistance to maize dwarf mosaic virus in the Southern Region (10 percent or less diseased plants). A technique for infecting leaf hoppers with maize rayado fino virus has been worked out. Successful transmissions of the MRFV has been achieved in which small amounts of purified virus are injected into the leaf hoppers which are then fed on test plants. Attempts to transfer MCDV (maize chlorotic dwarf virus) using this technique have been unsuccessful.

Pathological research on corn pathogens - W. Lafayette, IN, Columbia, MO Raleigh, NC, and Wooster, OH. Populations of Cochliobolus carbonus from three cornfields in different areas were sampled and are being analyzed to determine frequencies of alleles at genetic loci shown to be polymorphic. An inoculation chamber was designed and built to allow reproducible uniform disposition of fungi spores on plants. The chamber will be used in quantitative studies of virulence and resistance. Equilibrium conditions in a theoretical model of genetic interactions between host and pathogen populations were analyzed mathematically and numerically. The model suggests that genes for resistance that are most widespread and common in wild plant pathogens will be the most desirable for agriculture.

Developed basic biochemical knowledge to characterize the maize rayado fino virus. The buoyant density was determined to be 1.425 g/ml for the bottom component (RNA-containing) and 1.265 g/ml for the top component (empty shell). Both the top and the bottom components are composed of proteins of molecular weights of 21,000 and 25,500 with about three times as much of the former as of the latter.

Tryptic peptide analysis of the coat proteins of strains A, B, E and F of maize dwarf mosaic virus indicated that differences probably exist between some of the strains. No differences in the coat proteins of maize chlorotic dwarf virus type strain, severe strain, and another isolate of maize chlorotic dwarf virus were detected.

The role of Gibberella zeae on nitrate reductase systems, nitrogen metabolism and amino acid composition in seedling stages were studied. During late stages of infection many of the free amino acids declined. This was attributed to the utilization by the fungi.

Plant disease development and host-plant resistance under minimum tillage conditions were monitored using 9 inbreds susceptible to various specific pathogens. Only Helminthosporium turcicum was observed in the 1977 studies in northeastern Missouri.

Sorghum:

Developing breeding systems - Lincoln, NB and Manhattan, KS. The first year of a 2-year trial was conducted to test half-sib, full-sib, and S_1 families from population NP3R and S_1 's from population NP5R. The outstanding performing progenies will be used to establish a third cycle of the populations. High grain quality S_1 's from population RP1R and RP2B have been recombined. The two populations are early in maturity and have high greenbug resistance. In a test of 100 half-sib families, from RP1R, infested with European corn borer egg masses, yield was reduced 20 percent below the same families where insects had been controlled. Stalk and head breakage was 50 times greater in the infested treatment.

Selected sorghum lines with high grain yield potential, good greenbug and midge resistance have been recombined for a cyclic selection population.

Inheritance studies of cytoplasmic male sterile systems possessed by various sorghum lines resulted in the identification of several B-lines (maintainer) and R-lines (restorer).

Cytogenetics and genetic investigations - Lincoln, NB and College Station, TX. Two-year results from testing crosses with non-milo cytoplasms KS34A-KS39A did not reveal any effect on yield or other agronomic characters. A new cytoplasmic male sterile source and a maintainer line has been released - A2 Tx2753 and B Tx273. This new source of male sterile-genic restorer material has been distributed to 60 private and public breeders on request. These male steriles offer an alternative to the presently widely used milo-cytoplasmic system. The possible apomictic seed formation is under test in R473 and mutant marker types. Most progeny of apomictic parents were found to be cross incompatible.

Host-plant resistance to pest organisms - Tifton, GA, Lincoln, NB, Manhattan, KS, and College Station, TX. The sudangrass population resistant to downy mildew RSP3BR was released for germplasm purposes. This population also has some genes from resistance to anthracnose and greenbugs. A mass selection program involving 8 populations is being selected for midge, web worm, and aflatoxin resistance.

Progress in physiological research - Lincoln, NB. In desiccation studies sorghum strains showed less injury than corn strains, 10 percent versus 50 percent, respectively. The effective use of an osmotic chemical agent in the aqueous solution caused the reduction of 25 percent in photosynthesis and a yield reduction of 45 percent. In screening trials some seedlings showed 23 percent more drought resistance than the standard RS671 hybrid. Root characteristics between susceptible and drought resistant strains showed a lower shoot to root ratio for the resistant genotypes.

Sorghum lines have been shown to differ with respect to both phosphorus (P) and nitrogen (N) efficiency uptake from soil. Differential responses to N, P, and Fe (iron) efficiency and to aluminum (Al) tolerance were obtained when numerous plants were grown in the same containers. Soil surface residues reduced sorghum growth by reducing soil temperatures but did not influence mineral uptake in mature plants. Phosphorus (P) and potassium (K) did not influence protein quality in several sorghum strains.

Pearl millet - Tifton, GA and Manhattan, KS. Oviposition by corn earworms and fall armyworm was less in smooth-leafed pearl millet than on lines having leaf trichomes. Inheritance studies of cytoplasmic male sterile systems resulted in the identification of several B lines (maintainer) and R lines (restorer). Evaluation of germplasm in the fifth generation of selection resulted in a number of superior lines being identified with respect to agronomic and grain quality characteristics. The evaluation of 200 S₁ lines in a population showed a wide range in reaction to chinch bug damage, ranging from extreme susceptibility to a good degree of tolerance.

Technological Objective 2.

New and improved cultural and management practices that increase corn, sorghum and millet yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

Research Locations:

7702	Tifton, Georgia
3302	West Lafayette, Indiana
3608	Brookings, South Dakota

Selected Examples of Recent Progress:

Cultural and management practices - Tifton, GA, W. Lafayette, IN, and Brookings, SD. A short-season hybrid followed by a full-season corn hybrid for either grain or forage was the most economical double-cropping system in 1977 in southern Georgia. Kernel size did not influence resistant measurements of weevils in corn grain. Twenty weevils per sample was suggested with 1 gram of seed per weevil.

Effect of nitrification inhibitors on disease development, protein contents, and yield components was studied. There was a positive correlation between zein content, kernel weight, and grain yield. The quantity of zein produced varied according to the amount of nitrogen fertilizer available to the plant.

Near isogenic lines of opaque-2 and normal inbreds inoculated with Fusarium moniliforme showed resistance of opaque-2 and normal isogenic lines equal. However, in general, the infection was heavier on opaque-2 than on the normal counterparts. Anthracnose as free propagules in the soil showed conidia destroyed in 14 days at 16, 24, and 30° C. At 8°, 2 percent of the conidia was still viable after 100 days. Comparisons of corn rootworm infestation, an effect of levels of nitrogen and irrigation rates, were highly variable because of irregular rootworm infestation.

Four commercial corn lines were analyzed for possible corn rootworm antibiosis with negative results.

Appendix 1

Release of Germplasm Developments

Corn

<u>Date</u>	<u>State</u>	<u>Designation</u>	<u>Description</u>
4-77	MO	Mo40	Related to inbred line Mo17
		Mo41	" " " " "
		Mo42	" " " " "
		Mo43	" " " " "
1-78	NC	NC 1R10	Selected population of Indian Chief
		NC JR10	" " " Jarvis Golden Prolific
3-78	IA	B84	Inbred from BSSS(S2)C0 with good yield potential and intermediate resistance to first brood of European corn borer
		B85	Inbred from Iowa Corn Borer Synthetic # 6 with erect-leaf orientation and 2 days earlier than A632
		A632Rp	Rust-resistant strain of A632
		A635Rp	Rust-resistant strain of A635

Sorghum

1-77	TX	A2 Tx2753	New source of cytoplasmic male sterile; from a Caudatum-Nigricans type from Ethiopia
	TX	B Tx2753	The maintaner line for A2 Tx2753
5-77	KS	KS65A	A greenbug-resistant grain sorghum similar to Wheatland
		KS65B	The maintainer line
9-77	PR	PR3BR	Population of exotic varieties primarily for breeding programs in the tropics
11-77	KS	RSP3BR	Downy mildew resistant sudangrass population

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National Research Program 20050

BREEDING AND PRODUCTION - SMALL GRAINS (WHEAT, OATS, BARLEY, RICE, RYE, TRITICALE, WILD RICE, BUCKWHEAT)

This National Research Program involves research in breeding and production of the cereal small grains to develop new and improved genetic and cultural methods that will result in lower costs to consumers and increased efficiency of production for growers. Research agronomists, geneticists, plant pathologists, plant physiologists, cereal chemists, and other scientists work in a team approach to evaluate and improve small grain varieties and improve cultural methods.

NPS Contact: L. W. Briggie

PACS Contact: L. L. Jansen

Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of small grains that combine greater yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, responsiveness to new cultural and management practices, and adaptation for mechanized culture, harvesting, and handling.

Research Locations:

3611	Palmer, Alaska	3402	Columbia, Missouri
5502	Tucson, Arizona	5708	Bozeman, Montana
7406	Stuttgart, Arkansas	3416	Lincoln, Nebraska
5206	Davis, California	3602	Fargo, North Dakota
7602	Gainesville, Florida	3307	Wooster, Ohio
5703	Aberdeen, Idaho	7317	Stillwater, Oklahoma
3311	Urbana, Illinois	5809	Corvallis, Oregon
3408	Ames, Iowa	1302	University Park, Pennsylvania
3420	Manhattan, Kansas	3608	Brookings, South Dakota
7410	Crowley, Louisiana	7303	Beaumont, Texas
1108	Beltsville, Maryland	5702	Logan, Utah
3508	East Lansing, Michigan	5802	Pullman, Washington
3502	St. Paul, Minnesota	3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Small Grains in General:

Seed increase - Aberdeen, ID. Over 9,400 single or multi-row plots and about 4,100 spaced plants of oats, barley, and wheat were grown for 17 SEA/FR and AES projects located in 13 States in 1977. Included were portions of the World Small Grains Collection and future entries for the International Rust Nurseries.

Seed increase - Obregon, Mexico. Sixteen thousand forty-five durum and hard red spring wheat selections and genetic lines were grown in the winter increase program conducted cooperatively by SEA/FR and the Crop Quality Council. This service is provided to small grains research personnel in the spring grain area (primarily North Dakota, South Dakota, Minnesota, Montana). Use of this winter nursery allows an advance of an extra generation per year toward homozygosity, additional selection for favorable characters and disease resistance, plus seed increase for yield and quality tests. The program is administered through the Minnesota-Wisconsin-Michigan SEA/FR Area Office.

Variety and germplasm releases - U.S. Eight wheat, one oat, and one rice varieties were released cooperatively by SEA/FR and the State Agricultural Experiment Stations in 1977 (Appendix 1). One barley and 12 rice germplasm populations were released by the same agencies in 1977 (Appendix 2).

Special nurseries - Beltsville, MD. Four international and five uniform wheat and oat nurseries were prepared in 1977 and distributed to 191 locations in 44 countries. In addition, two more wheat international nurseries were distributed from Lincoln, Nebraska, and approximately 20 uniform nurseries involving wheat, oats, barley, and rice were distributed within the U.S. from project locations other than Beltsville. Most of the latter are performance nurseries where advanced breeding lines are tested for characters such as yield, disease resistance, and lodging resistance.

Wheat:

High yielding varieties released - Aberdeen, ID. 'Fieldwin,' new soft white spring (SWS), has a 7 percent yield advantage over 'Fielder' on the basis of three years' testing under irrigated conditions in Southern Idaho. 'Sawtell,' new hard red winter (HRW), has a 9 percent yield advantage over 'Borah,' under both dryland and irrigated tests in Idaho. It has, however, about one percent lower protein than Borah. Both wheat varieties were developed cooperatively by SEA/FR and the Idaho Agricultural Experiment Station.

New soft red winter wheat released - Urbana, IL. 'Roland,' released jointly by SEA/FR and the Illinois Agricultural Experiment Station out-yields 'Abe,' a very popular wheat variety at present, has better lodging resistance, better milling and baking qualities, but is lower in test weight and slightly later in maturity. It has some tolerance to barley yellow dwarf virus. Its reaction to other diseases and insects is similar to that of 'Arthur.'

Quality testing of Hard Red Winter Wheat - Manhattan, KS. About 1,200 early generation breeding samples were analyzed for grain protein. Several contained from 1.5 to 5.3 percentage points more protein than control varieties. About 1,200 early generation progenies were micro-milled and evaluated for milling properties. About 385 samples of agronomically promising advanced lines and recently released varieties were characterized for their milling and baking properties.

Concern over coumestrol in wheat flour blends - Manhattan, KS. Coumestrol is an estrogenic compound found in many forage crops. Recently there has been a great deal of interest in blending flour from crops other than wheat that may contain coumestrol. For example, flour from sprouted alfalfa and soybeans contain coumestrol. Because the use of forage plants in both human and animal nutrition is increasing, a quick and reliable analytical method is desirable for measuring coumestrol. The Hard Red Winter Wheat Quality Laboratory is presently trying to find a rapid and effective measure of coumestrol. It can be quickly determined analytically by high performance liquid chromatography. This analytical method was effective from 0.1 ppm to 100 ppm of coumestrol in soybean extracts.

Effect of powdery mildew on wheat - Beltsville, MD. Wheat plants infected with mildew and grown in liquid nutrient culture suffered a 36 to 49 percent reduction in root length, a 45 to 58 percent reduction in root weight; stems were 13 to 14 percent shorter, and 48 to 60 percent lower in weight than noninfected check plants. The magnitude of wheat yield loss in the field from powdery mildew was measured in a study recently completed. Over one-fourth of the potential yield was lost. With an infection level of 100 percent, it is estimated that over half the yield would be lost. While the disease severely decreased yield, it did not affect soft wheat baking quality of the grain.

New hard red spring wheat variety released - St. Paul, MN. 'Angus' was developed jointly by USDA, SEA/FR and the Minnesota Agricultural Experiment Station. Angus is as high yielding as 'Kitt,' but has better bushel weight. It has higher grain protein and a different source of leaf rust resistance than does 'Era.' Angus is equivalent to 'Chris' and superior to Era in water absorption of flour and in loaf volume. Angus is a significant contribution because it provides an alternative high yielding, high quality bread wheat for growers.

Leaf rust resistance from related species - Columbia, MO. The combination of three different sources of leaf rust resistance has been obtained by introduction of alien chromosomes from related species. Plants are now available that have two *Agropyron* resistances in the homozygous state. The third source of resistance is from *Aegilops umbellulata*, but this resistance is heterozygous at this point. Further work is necessary to get all three in the homozygous state.

Isogenic height levels established in wheat - Bozeman, MT. Three different isogenic height levels, in a background of 'Rescue' spring wheat, have been established. These lines are now available to agronomists or geneticists as test material for morphology, genetic, physiology, developmental or biochemical studies.

Significant differences in vernalization requirements of Nebraska winter wheat varieties - Lincoln, NE. The daylength-sensitive winter varieties 'Lancota' and 'Centurk' differ in their cold requirement needed to trigger reproduction and seed production. Lancota has a short cold period requirement whereas that of Centurk is longer. Varieties like Lancota could have special usefulness in regions of very mild winters where they can provide additional winter grazing, as well as a grain crop.

Productive high protein, high lysine wheats identified - Lincoln, NE.

Experimental lines of winter and spring wheat that were consistently higher in protein and lysine than ordinary varieties at 16 international test sites have been identified. This was accomplished through the International Winter Wheat Performance Nursery. The same lines referred to above were high yielding as well as high in grain protein and lysine in an irrigated replicated yield nursery grown at Yuma, Arizona. These lines are being used by wheat breeders in several countries as well as in the U.S. to develop new productive varieties that are more nutritious.

Set of D genome substitution monosomics developed for durum wheat -

Fargo, ND. A complete set of the D genome substitution monosomics in durum wheat was developed and is available to scientists. This set of lines can be used to locate genes on specific chromosomes of durum wheat in the same way the hexaploid monosomics are used in hexaploid wheat. This new set of material will be of considerable use in obtaining a better understanding of the genetics of durum wheat (which is a tetraploid).

Stem rust resistant wheats released - Fargo, ND. One hard red spring wheat named 'Coteau' and two durum wheats named 'Calvin' and 'Edmore' were developed cooperatively by SEA/FR and the North Dakota Agricultural Experiment Station (release was by the North Dakota Agricultural Experiment Station only). In addition to desirable agronomic and quality characteristics, these varieties show superior levels of stem rust resistance necessary for maintaining protection against this catastrophic disease. Calvin and Edmore were immune to stem rust infection in three years of field trials, and Coteau had a lower coefficient of infection than currently grown hard red spring wheat varieties.

High fiber bread - Fargo, ND. Bread produced from hard red spring wheat flour plus an added bran fraction to increase the fiber content has significantly reduced blood serum cholesterol in human subjects when tested in an extensive diet experiment at the SEA/FR Human Nutrition Laboratory in Grand Forks, North Dakota. Bran obtained from Western white wheats did not have the same effect. Wheat brans from different classes of wheat may have different influences on blood cholesterol. This was a preliminary experiment and further research is necessary before definite conclusions are reached.

Quality testing of hard red spring wheat - Fargo, ND. Quality evaluation tests were performed on 1,039 samples of hard red spring wheat and 526 samples of durum. HRS samples were received from 8 States and durum samples from 6 States. An additional 22 large-scale Crop Quality Council wheat lots were processed for evaluation by the HRS Wheat Quality Laboratory and by industry participating collaborators.

Quality testing of Eastern soft red winter and white wheats - Wooster, OH.

A total of 1,156 samples from breeding programs and uniform performance nurseries were tested for soft wheat milling and baking quality. An additional 2,572 samples were evaluated under the early generation screening program.

Improved evaluation tests for soft wheat quality - Wooster, OH. A new soft wheat milling technique has been adopted which subjects each experimental sample to conditions best suited for that particular type, rather than the former uniform procedure for all samples. This procedure more nearly resembles commercial milling. The technique for evaluating early generation samples for soft wheat quality has been modified. Processing time is shortened by about 30 percent. This results in a significant increase in number of samples that can be tested. These two accomplishments contribute to the eventual upgrading of soft wheat quality for both domestic and export markets. A third procedure, a rapid particle size index method, has been developed to measure kernel texture of grain. This is particularly useful because it readily distinguishes soft wheat from hard wheat.

Transfer of greenbug resistance from rye to wheat - Stillwater, OK. Research which resulted in gene transfers to wheat from rye for disease and insect resistance has led to the release of 'Amigo,' a greenbug resistant wheat germplasm. This is the only known source of resistance in wheat to the greenbug. Amigo was developed from a cross involving wheat with a resistant Argentine rye. The new line is stable for resistance and has no deleterious characters from rye. Thus far seed stocks of Amigo have been sent to over 30 wheat breeders in the U.S., Mexico, Brazil, Argentina, and Australia. An added bonus from the rye parent is resistance to powdery mildew.

Interspecific hybrids as sources of resistance to smuts of wheat - Corvallis, OR. Interspecific crosses were made and steps are underway to transfer outstanding smut resistance from *Triticum monococcum*, a diploid relative, and *Triticum timopheevi*, a tetraploid relative of hexaploid wheat. This procedure is difficult and will take time, but results are promising.

Improvement of triticales lines - Corvallis, OR. Thirty-five out of 66 advanced generation winter triticales lines survived the winter at Edmonton, Canada. Both winterhardiness and seed quality have been improved in semidwarf types. Several of these equaled or exceeded adapted wheats in grain yield.

Effective resistance to common bunt - Logan, UT. Forty spring wheat and winter wheat selections were resistant at all locations when tested to key races of common bunt. Most of these derive resistance from P.I. 178383 (*Bt* 9 and *Bt* 10) or these genes in combination with the Rdit gene, *Bt* 3. A few selections incorporated resistance from new sources such as C.I. 9342, C.I. 14106, and P.I. 173438.

Concern over dwarf bunt in the Pacific Northwest - Logan, UT. Dwarf bunt infection during 1977 was low due to lack of snow cover and other environmental conditions, but results supported evidence obtained in previous years, that there is wide distribution of new races of dwarf bunt that can attack most, if not all, wheat varieties presently grown in the Northwest.

Quality testing of Western wheats - Pullman, WA. A total of 770 advanced selections were evaluated for milling and baking quality. Milling quality of 1,781 F₄ and F₅ selections was determined, as was micro-milling quality of an additional 1,245 samples. Grain samples from 2,092 early generation hard red winter selections were screened for protein and 564 of these were analyzed for lysine with near infrared equipment.

Germinated wheat has improved nutritional value - Pullman, WA. Five Pacific Northwest wheat varieties were germinated under controlled conditions. The important limiting amino acids, lysine and tryptophan, were increased by 35 and 45 percent, respectively. 'Nugaines' and 'Twin' produced the greatest increases in lysine and 'Fortuna' showed the highest increase in tryptophan. These wheat malts can comprise from 13 to 55 percent of a blend with wheat flour for baking bread. Breads made from such blends have advantages beyond improved amino acid balance, in that they provide needed fiber with reduced phytic acid levels, and they have higher levels of several vitamins.

New lysine method - Pullman, WA. A rapid technique for measuring lysine with the infrared analyzer was worked out which permitted analysis of the 465 selections referred to above for lysine while simultaneously measuring the protein. This new test for lysine represents a significant advancement in development of wheats and other cereals with improved nutritional quality. Several hundred samples per day can be determined at less than one hundredth the cost by the chemical method.

What makes a good Japanese sponge cake - Pullman, WA. Flour reconstitution studies showed that gluten proteins are the key constituents in Japanese sponge cakes. By testing wheat samples that vary widely in protein and which had been grown during different seasons, the optimum protein ranges for sponge cakes were determined for three market classes of soft wheat. A simple traditional test (viscosity test) was shown to have potential for identifying those soft white wheat selections which make the best Japanese sponge cakes. These findings will help insure delivery of high quality wheat to one of this country's best export customers.

Multiline varieties offer hope for controlling stripe rust - Pullman, WA. Multiline varieties have performed well in Eastern Washington for three years. Multilines are mixtures of plants that have different types of resistance rather than the single uniform type in most conventional varieties. Because their resistance is diverse and not uniform, they are not vulnerable to new virulent stripe rust races. Yield tests show multilines usually exceed the average yield of the component lines. Multiline variety yields are more stable; they have broader adaptation among the diverse environments of the Pacific Northwest than do their components.

Drought of 1977 helped identify foot rot and drought tolerant wheat germplasm - Pullman, WA. Forty-nine wheat selections among 1,810 tested showed superior tolerance to dryland Fusarium foot rot. Until then it was doubtful that high tolerance to dryland foot rot was even present in wheat. Most of the better lines are hard red winter types. They will be used as parents in crosses with local adapted varieties.

Breeding may help solve sprout damage problems in wheat - Pullman, WA. Sprout damage caused by high alpha amylase activity lowers the export quality of Western white wheat. Several white-seed lines maintained high falling number values (low alpha amylase activity) after exposure to rain. 'Brevor' (white seed) type dormancy was more effective in preventing sprouting than red seed types 'Itana' and 'Nord.' Breeding for resistance to sprout damage will not be easy in white wheat because lines that do not sprout when grown at one location may sprout at another. Lodging resistant, strong strawed, awnless, medium tall, semidwarf lines generally suffer less sprout damage than other types. Studies have shown that germination rate (promptness index score), measured on mature grain just after harvest and before receiving rain damage, correlates closely with falling number value measured after wheat has received rain damage. By measuring the promptness index values of breeding lines during a dry harvest season, we should be able to predict how well they will resist sprouting during a wet season.

Oats:

Generalized or horizontal resistance - Gainesville, FL. Generalized resistance to crown rust of oats and other appropriate pathogens is a more stable type which is not affected by shifts in races of the pathogen when compared to specific resistance. Field experiments indicated that crown rust in oats spreads very slowly in varieties with generalized resistance, compared to susceptible varieties and to equal mixtures of plants susceptible and resistant, or susceptible and intermediate types. This indicates that varieties having generalized resistance would not become highly infected, and epidemics very likely would not occur. If generalized resistance can be genetically manipulated by breeders, it could represent a very significant step forward in control of such diseases as crown rust of oats.

Genetic control of virus multiplication - Urbana, IL. SEA/FR scientists located at the Illinois and Cornell Agricultural Experiment Stations have jointly demonstrated that tolerance to barley yellow dwarf virus in oats is related to low virus concentration in infected plants. This character is transgressively inherited, giving higher or lower levels of tolerance from those of the parents. It is feasible, therefore, to improve upon the tolerance of parent lines by proper breeding procedures.

Experimental oat lines resistant to crown rust - Ames, IA. Genes in the wild Mediterranean oat *Avena sterilis* were transferred to cultivated type oats. Several oat lines representing different resistance genes were tested over a 5-year period to more than 2,300 cultures of crown rust collected over the U.S. Two of the resistance genes conditioned resistance to all crown rust cultures, suggesting that they might be very useful in breeding commercial oat varieties with more effective resistance to crown rust.

Resistance to barley yellow dwarf virus from wild oats - St. Paul, MN and Urbana, IL. In a replicated test of *Avena fatua* lines which had shown promise during initial screening, 34 showed high tolerance to barley yellow dwarf virus in recent tests. Barley yellow dwarf is an

insect-vectored virus that is presently considered to be the number one disease of oats in the U.S. It also affects barley and wheat. Because the wild oats can be easily crossed with common oats (*Avena sativa*), the virus resistance should be readily transferable.

Improved test for cold hardiness - University Park, PA. An improved technique for measuring cold hardiness in oats is based on the fact that slight variations in crown moisture cause intra-variety variations in freezing resistance. Experimental error was reduced by pre-sprouting seeds, growing the plants in nutrient culture, and preconditioning the crowns prior to freezing. Juvenile plants are grown in small tubes partially immersed in nutrient solution. The individual plant crowns are frozen after removal of leaves and roots. Survival is based upon regrowth after freezing. This technique has been precise enough to sort out superior individuals in a population. The new procedure compares favorably with field tests, which are slow, costly, and generally unreliable.

Quality testing of oats - Madison, WI. In 1977, 38,304 oat samples were analyzed for groat protein at the National Oat Quality Laboratory. Of these, 36,528 were analyzed by the dye-binding method, and 1,776 by the Kjeldahl method. Not included in these numbers were Kjeldahl checks performed on 675 samples, selected at random, which were previously analyzed by dye-binding to make certain the comparability between the two methods. Cost of analyses, based on labor and materials only, for the dye-binding and Kjeldahl methods, was about 72 cents and 93 cents per sample, respectively. A near infrared analyzer has been procured for use in the laboratory during 1978.

Barley:

Hulless barley for Alaska - Palmer, AK. Initial purification of a hulless barley selection was completed. This will be used for breeder's seed increase. Hulless barley is of interest in Alaska for possible export to Asian markets.

Use of male sterility to facilitate genetic recombination - Tucson, AZ. Genes for genetic male sterility are being used in a system known as "male sterile facilitated recurrent selection" to build genetic populations for several characteristics in spring barley. Among them are populations involving (1) short straw, (2) large awns, (3) thick stem walls, (4) acceptable yield with only one preplant irrigation, and (5) early maturity which could be used in double-cropping systems with corn and sorghum. Still another population involves genotypes tolerant to aluminum toxicity resulting from acid soil conditions. Some of these same characteristics are being integrated into winter barley populations via the same system.

A new high-yielding malting barley - Aberdeen, ID. 'Kimberly,' a two-row spring barley, has been recommended by the Mid-West Barley Improvement Association as an acceptable malting and brewing barley. It was developed by SEA/FR and the Idaho Agricultural Experiment Station. Kimberly yields about 5.3 percent more than 'Klages' and is similar in

malting quality. It is expected to offer a definite yield advantage over presently grown barley in the Upper Snake River Valley, Camus Prairie, and Palouse areas in the Pacific Northwest.

New information obtained and techniques developed for studying barley leaf rust - Beltsville, MD. Information which may reduce losses from barley leaf rusts has been obtained from the study on evolution, host resistance, and pathogen virulence in Israel. Cultures of the pathogen causing barley leaf rust were isolated which are virulent on the barley variety 'Cebada Capa.' This variety has been resistant to all cultures in the U.S. and in many other countries. It is the source of resistance in many varieties presently grown in the U.S.

A procedure for facilitating crossing and hybridizing of *Puccinia hordei* and *Uromyces* rust species (within each species; not between species) was developed to study the origin of new pathogenic races of the two leaf rust pathogens. The life cycle of the rusts can be completed in about 40 days by using detached leaves of the alternate host in the case of *P. hordei* and segments of fleshy bulb scales in the case of *Uromyces*. The alternate host of both rusts is *Ornithogalum*. Information obtained from studying pathogenicity of both rusts and the life cycle of *Uromyces* species resolved many questions concerning pathogenicity of the rusts.

Freeze test procedure proposed - E. Lansing, MI. A proposal was presented outlining a plan for a procedure in which barley and wheat genotypes could be tested to 5 different forms of low temperature stress, each of which is a component of winterhardiness or tolerance to low temperature. Basic research based on cryoprotection provides the basis for the 5 tests. It is hoped that the multi-test procedure can be used for effectively screening segregating progenies of winter wheat, barley, and oats for low temperature tolerance.

Two new spring feed barleys - Bozeman, MT. 'Ershabet' and 'Ridawn' are new spring barleys developed by SEA/FR and the Montana Agricultural Experiment Station. Ershabet is especially useful where early maturity is desired and Ridawn is a special forage-type barley developed for hay and forage use. Ridawn is an awnless barley.

High oil concentration in barley grain - Brookings, SD. A total of 17,318 entries in the World Barley Collection have been analyzed for oil content by NMR analysis. Five of the highest barleys have been selected and are now involved in a diallel crossing program. The intent is to accumulate genes for high oil in barley, and thereby improve the nutritional quality of barley as a feed crop.

Quality testing of barley - Madison, WI. A total of 4,000 barleys from the 1976 crop and 3,100 from the 1977 crop were analyzed for malting quality. Samples were received from about 12 State and Federal breeding programs.

Protein in 'Karl' barley - Madison, WI. Karl was released in 1974 by SEA/FR and the Idaho Agricultural Experiment Station. It is lower in protein and higher in malt extract than other six-row malting barleys.

Karl has an altered protein distribution--20 percent more salt solubles and 25 percent less hordein than conventional malting six-row barleys. The lower hordein level is particularly desirable since hordein is only partially utilized during malting and brewing. Use of Karl-type genes in other breeding programs may solve long-standing problems with high protein malting barleys.

Dietary fiber in brewers' spent grains - Madison, WI. Research at the Barley and Malt Laboratory has shown that brewers' spent grain is high in dietary fiber (about 40 percent) and has 30 percent protein. Work with consumer panels indicates that about 15 percent of the wheat flour in bread and cookies can be replaced by brewers' spent grain. These findings have opened a new potential use for this by-product, which heretofore has been utilized mainly as cattle feed and has brought a relatively low price.

Rice:

New lodging resistant rice variety - Stuttgart, AR. A new short straw, short season, medium grain variety named 'Mars' has recently been released by SEA/FR and the Arkansas Agricultural Experiment Station. In addition to having stronger straw than available medium- and short-grain cultivars, the milled kernels of Mars are less chalky than those of popularly grown medium grain varieties. Mars is resistant to the two races of rotten neck blast fungus which can cause severe damage to fields of other varieties. Mars has been approximately equal to the high yielding 'Nortai' and 'Brazos' varieties in grain production. Mars is expected to replace most of the current acreage of other medium-grain cultivars in Arkansas, and may be grown extensively in Louisiana.

Rice germplasm released - Davis, CA. Four short-stature lines, two early-maturing lines, and six lines resistant to low temperature induced sterility, have been released for use by rice breeders in the U.S. and similar high latitude areas worldwide. Eight more semidwarf rice lines, all derived from cold tolerant 'Calrose 76,' were turned over to the California Co-operative Rice Research Foundation for use in the breeding program at Biggs, California.

Short stature rice lines with high milling quality for the Gulf States - Crowley, LA. A significant improvement in milling yield was realized from a group of short stature, long-grain types which have good plant type, lodging resistance, and resistance to several diseases. Several averaged more than 60 percent whole kernel milled rice. These are not yet varieties but will be excellent parents to use in various recombination experiments.

Source-sink relationships in rice - Beaumont, TX. Studies of various rice plant types indicate a strong negative relationship between leaf size and grain yield under gulf coast environments. This may provide an important selection index to rice breeders in developing very high yielding cultivars. Observations suggest that sink size is not limiting yields in Texas. Source is generally not limiting, and the primary impediments to higher yields seem to involve hormonal action that in turn control translocation and partitioning of assimilates in the plant.

Resistance to blast (*Pyricularia oryzae*) - Beaumont, TX. Preliminary genetic evidence suggests that combinations of 'LaBelle' or 'LaBonnett' with 'Gulfrose' offers resistance to all present races of blast.

Quality testing of rice - Beaumont, TX. Over 10,000 experimental and advanced selections from cooperative Federal-State programs in Texas, Louisiana, Arkansas, Mississippi, and California were evaluated for specific milling, cooking, processing, or nutritional quality. Amylose content, alkali spreading values, parboil-canning stability, paste viscosity, and protein levels were determined as predictors of quality.

Technological Objective 2.:

New and improved cultural and management practices that increase small grain yields through disease, insect, and weed control; that minimize environmental stress; that improve physical and nutritional quality attributes; that minimize production losses; and that conserve and more efficiently use scarce or irreplaceable resources.

Research Locations:

3611	Palmer, Alaska	1302	University Park,
7602	Gainesville, Florida		Pennsylvania
5703	Aberdeen, Idaho	3608	Brookings, South Dakota
3311	Urbana, Illinois	7303	Beaumont, Texas
3420	Manhattan, Kansas	5702	Logan, Utah
3416	Lincoln, Nebraska	5802	Pullman, Washington
5809	Corvallis, Oregon	3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Wheat:

Delayed seeding of winter wheat controls soilborne wheat mosaic - Urbana, IL. Soilborne mosaic, a scourge of winter wheat in the Great Plains, can be controlled by proper dates of planting. Susceptible wheats can escape infection when proper time of seeding is used in mosaic-infested soil. Three susceptible winter wheat varieties planted on September 4 yielded an average of 12 q/ha while the same varieties planted on October 11 and 27 yielded 32 and 36 q/ha, respectively. Results varied from 100 percent infection of the September 14 planting compared to 0 percent for the October 27 planting. Disease incidence and severity in the wheats were correlated with depression in yield.

Germination inhibitor extracted from dwarf bunt spores - Corvallis, OR.

An endogenous germination inhibitor was extracted from spores of the dwarf bunt fungus and purified by chromatographic procedures. The structure of the compound was studied by infrared, NMR, and mass spectrometric analyses through which molecular weight and structure were determined. Since more specific and effective controls are needed for bunt diseases of wheat, identification of this and other inhibitors should help in development of highly specific and effective multi-inhibitor preparations with which to better control bunt diseases of wheat.

Effect of virus on genetics of plant characters - Lincoln, NE. A series of aberrant ratios for aleurone color in certain corn stocks indicated a virus-induced anomaly in segregation of A_1 alleles. Apparently a linked or unlinked recessive suppressor is involved, and the aberrant ratios may be due to suppression of any one of the A_1 , A_2 , C_1 , C_2 , or $R+$ alleles. Some corn lines were susceptible at 35°C., whereas the reverse was true for susceptibility to wheat streak mosaic virus. Susceptibility of 52 corn inbreds and 152 commercial hybrids to wheat streak mosaic virus after both manual and mite inoculation was determined. Most hybrids were resistant; some inbreds susceptible.

Seed treatment fungicides for soilborne common bunt and dwarf bunt - Logan UT. Relatively few new candidate fungicides are being submitted for testing. The only new material that showed effectiveness against seedborne common bunt was RH 2161. Materials continuing to show effectiveness against both seed and soilborne common bunt were HCB, PCNB, TBZ, carboxin, furavax, Baymeb 6447, and RH 2161. Previous studies indicated that dwarf bunt could be effectively controlled by seed treatment with furavax or TBZ if seeding is delayed until October 15. Additional studies are needed to confirm this finding.

No-till may eventually raise winter wheat yields - Pullman, WA. Although yields on no-till are presently lower than conventional management, fumigation studies show that the production potential may actually be higher than with conventional tillage *when soil pathogens and weeds are controlled*. Fumigation studies demonstrated that yet unknown soil pathogens claim 10 to 40 bushels per acre in Pacific Northwest wheat fields.

Take-all disease is especially severe under no-till management - Pullman, WA. No-till management in the Pacific Northwest increases take-all of both spring and winter wheat, emphasizing the need for control of this disease. Fumigation showed that diseases other than take-all also must reduce yields. Additions of phosphorus and certain trace elements helped to reduce take-all damage under no-till.

No-till wheat production may require specific plant types - Pullman, WA. Initial tests under no-till management showed that wheat selections with club heads and without awns yielded better than other types. Lines of the semidwarf type which have yielded so well under conventional tillage appeared to lack adaptation to no-till.

Selective fungicides help identify wheat disease losses - Pullman, WA. Selective fungicides were used to separate the effects of stripe rust, leaf rust, and powdery mildew on yield of Pacific Northwest wheat varieties. Stripe rust caused losses of 11 to 25 percent and 30 to 45 percent at some locations in Eastern and Western Washington, respectively. Leaf rust was not considered to be severe in 1977, but it reduced the yield of one variety by 17 percent. Even though the incidence of powdery mildew was severe, no losses were actually measurable.

Oats:

Cereal forage trials produce very high yields under irrigation, especially oats - Aberdeen, ID. Cereal forage trials that include 'Twin' spring wheat, 'Klages' and 'Steptoe,' spring barley, and 7 oat varieties and selections, indicated high dry matter yields (at about 10 percent moisture). 'Otana' averaged highest in dry matter yield among oat varieties with more than 10,000 pounds per acre. Close behind Otana was Klages barley. 'Cayuse' and 'Park' oats averaged 8,892 and 9,883 pounds per acre, respectively. The 7 oat entries in the trial averaged 9,799 pounds per acre.

Early planting of forage cereals in the Southeast results in severe disease problems - Gainesville, FL. Early forage from cereal crops is needed to improve beef production efficiency. Early planting, however, results in severe losses due to warm weather soilborne pathogens. Experimental results show that oats are more tolerant to warm weather pests than rye and that the combination of two fungicides is needed to increase forage production.

Effective management practices for semidwarf spring oats - University Park, PA. The average yield of an experimental compact-panicle semidwarf was not affected by seeding rate (60 to 120 pounds per acre), but a 21 percent increase in yield resulted when row spacing was reduced from 7 inches to 5 inches. Increased nitrogen from 40 to 100 pounds per acre gave a 30 percent yield increase at the 7-inch row spacing, compared to 47 percent at the 5-inch row spacing. The maximum mean yield of semidwarf types was 113 bushels per acre. Premature loss of green leaf area and low test weight (weakness of the semidwarfs) were not offset by high nitrogen.

Basic research on oat protein - Madison, WI. A study is underway to establish the relationship between uptake, metabolism, and transport of nitrogen in the oat plant to grain protein. A complex procedure has been devised to determine the nature of supply of assimilates to developing seeds. This supply will be manipulated experimentally, and the effects on seed composition noted.

Small Grain Varieties Released in 1977

<u>Name or Designation</u>	<u>Class or Type</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>WHEAT</u>			
Fieldwin	Soft White Spring	SEA-Idaho, Oregon, & Colorado AES	Higher yield than Fielder, improved test weight.
Newton	Hard Red Winter	SEA-Kansas, Oklahoma, & Texas AES	Short stature, resistance to lodging, resistance to soil- borne mosaic.
Parker 76	Hard Red Winter	SEA-Kansas AES	Superior to Parker in resistance to leaf rust and stem rust.
Payne	Hard Red Winter	SEA-Oklahoma AES	Lodging resistance, leaf rust resistance.
Rall	Hard Red Winter	SEA-Oklahoma AES	Some tolerance to wheat streak mosaic virus and to drought.
Roland	Soft Red Winter	SEA-Illinois AES	High yield, short stature, resistance to lodging.
Sawtell	Hard Red Spring	SEA-Idaho, Oregon, & Washington AES	Higher yield than Borah, moderate resistance to prevalent races of stripe and leaf rust.
Sullivan	Soft Red Winter	SEA-Purdue AES	Earlier in maturity than Oasis, moderate resistance to "take-all" foot rot.
<u>OATS</u>			
Corbit	Spring	SEA-Idaho & Oregon AES	Increased yield and test weight under irrigation, resistance to lodging.

Appendix 1

<u>Name or Designation</u>	<u>Class or Type</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
RICE			
Mars	medium-grain	SEA-Arkansas AES	Short stature, resistance to lodging, resistance to <i>Pynicularia oryzae</i> which causes rotten-neck blast.

Small Grain Germplasm Released in 1977

<u>Name or Designation</u>	<u>Release Agencies</u>	<u>Reason for Release</u>
<u>BARLEY</u>		
Composite Cross XXXII	SEA-Arizona & Montana AES	Short stature, resistance to lodging.
<u>RICE</u>		
C.I. 11033 to 11036 (4 lines)	SEA-California AES & California Co-Operative Rice Research Foundation	Short stature, resistance to lodging.
C.I. 11037 & 11038 (2 lines)	SEA-California AES & California Co-Operative Rice Research Foundation	Early maturity.
C.I. 11039 to 11044 (6 lines)	SEA-California AES & California Co-Operative Rice Research Foundation	Resistance to low temperature induced sterility.

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National Research Program 20060

BREEDING AND PRODUCTION - COTTON

Cotton fiber, and food and feed from cottonseed are vital national resources. The mission of this national research program is to develop new knowledge which will increase the production efficiency of this basic crop and provide consumers with a stable supply of fiber and food at a reasonable cost. The research approaches emphasize genetic improvement and the development of more efficient cultural and management practices.

NPS Contact: P. A. Miller

PACS Contact: L. L. Jansen

Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of cotton that combine increased yield potentials and favored quality characteristics of seed and lint with increased resistance to pests, tolerance to environmental stresses, and adaptation to modern cultural, harvesting and handling practices.

Research Locations:

7506	Auburn, Alabama
5510	Phoenix, Arizona
5206	Davis, California
5203	Shafter, California
7502	Mississippi State, Mississippi
7402	Stoneville, Mississippi
5507	Las Cruces, New Mexico
7802	Raleigh, North Carolina
7709	Florence, South Carolina
7806	Knoxville, Tennessee
7203	Brownsville, Texas
7302	College Station, Texas
7311	El Paso, Texas
7313	Lubbock, Texas

Selected Examples of Recent Progress:

Basic Genetics and Expansion of Germplasm Base:

Cell culture methods improved - Las Cruces, NM. Improved liquid nutritional media were established that doubled growth rates of cell suspension cultures and improved their reestablishments on agar. The use of vitamin E and increased iron concentration led to rapidly growing juvenile liquid suspension cultures. It was found that haploid cells grew four times faster in liquid culture than the diploid cells, giving an excellent means of selecting and producing haploid tissue from cotton pollen. Regeneration of plantlets from tissue cultures, however, has still not been achieved.

Development of scheme for breeding strains of cross-incompatible cotton - Raleigh, NC. Basic genetic studies on the inheritance of cross compatibility of our cultivated cottons with a wild species, Gossypium davisonii, have led to the development of a scheme for breeding strains of cotton which would be incompatible with existing cultivars. Such a mechanism would be very useful, for example, in preventing contamination of glandless cottonseed in commercial production fields from natural outcrossing with glanded types.

Embryo culture technique improved - Knoxville, TN. The in-ovule technique of embryo culture has been improved sufficiently to permit the successful hybridization of distantly related cotton species. For example, successful hybrids have now been established between cultivated American cottons and a wild Australian species. This technique provides the potential for significantly expanding our germplasm base for the genetic improvement of cotton.

New cotton germplasm introduced - College Station, TX. Botanical field work in the tropics has led to the addition of two new wild species of cotton to the germplasm collection. In addition, newly collected germplasm of primitive and cultivated strains of our commercially grown cottons have also been introduced. These introductions provide new sources of germplasm for cotton breeders.

Developmental Breeding for Host Plant Resistance:

Precise root-knot nematode resistance evaluation techniques developed - Auburn, AL. Techniques have been developed which permit identification of cotton plants with resistance capable of reducing root-knot egg laying to the point that the nema's life cycle can be broken. Resistant plants identified with these techniques reduced oviposition from over 100,000 eggs to less than 500 eggs per plant. These techniques provide the potential for developing cotton varieties capable of preventing economic loss from root-knot damage without depending on the use of chemical pesticides.

Root-knot resistant breeding lines released - Shafter, CA. Four non-commercial breeding lines with moderate resistance to root-knot nematodes and having good agronomic and fiber quality characteristics were released.

Insect and disease resistant cotton lines developed - Mississippi State, MS, and Auburn, AL. Sixteen cotton lines which are highly resistant to Fusarium wilt, one cotton line resistant to lygus and Fusarium wilt, 19 cotton lines with moderate levels of resistance to boll weevil oviposition, and 12 lines with resistance to Cercospora leaf spot have been identified. Seed of these lines are being increased for a non-commercial germplasm release.

New source of insect resistance - Florence, SC. Resistance to the bollworm/budworm complex has been found in Pee Dee breeding line, PD 4461.

The nature of the resistance has not been identified, but square damage and live worms are generally reduced by 1/2 on resistant lines. The new resistance is different from that ascribed to the terpenoids and should be useful in breeding resistant varieties that require less insecticide.

Improved lines of high bud gossypol cotton developed - Brownsville, TX. Two cotton lines with increased levels of terpenoids in the flower buds were identified which were agronomically competitive with commercial varieties of cotton in the Rio Grande Valley in 1978. These lines show significantly increased resistance to the bollworm and budworm complex when compared to present commercial varieties.

Natural pesticides in cotton pigment glands discovered - College Station, TX. The small, dark pigment glands that occur below the surface of cotton leaves and stems were shown to contain natural pesticidal chemicals. Fifteen of these chemicals were isolated from different species of cotton. These were identified as different terpenoids. The terpenoids are toxic to fungal pathogens and to tobacco budworms and bollworms. Individual terpenoids, however, vary considerably in their toxicity to specific pests. Genetic studies further showed that it is possible to breed for any of twelve different combinations of these terpenoids in cotton tissues. These studies indicate that resistance of cotton to pests can be improved by the genetic manipulation of specific natural chemicals.

Developmental Breeding for Agronomic Traits:

Varietal release of Pima cotton widely grown in the Southwest - Phoenix, AZ, and Knoxville, TN. Pima S-5 released by SEA-FR in 1975 for commercial production has been well accepted by producers for its high production and by processors and consumers for its high fiber quality. This variety constituted 100% of the 1977 Pima acreage in the Phoenix territory and 94% in the El Paso territory. Gross farm value of the cotton produced totaled over \$30 million.

Acala variety released for San Joaquin Valley - Shafter, CA, and Knoxville, TN. Seed of Acala SJ-5 are being increased to replace the currently grown SJ-4. This new variety surpasses SJ-4 in all important characteristics including higher lint yield, improved seed quality, and better Verticillium wilt resistance combined with the premium Acala fiber quality. The fiber yield increase of 10% alone could mean an additional \$50 million to California cotton growers.

New instrument developed for improving "stormproofness" - Lubbock, TX. This new instrument can quantify small degrees of the stormproof trait in cotton. Stormproof cotton varieties are grown in the Southwest where open cotton bolls must remain on the plants until 90-95% of the crop is open for once-over stripper harvesting. This instrument will help plant breeders to develop cotton varieties more able to withstand the high winds, rain, ice, and snow storms that characterize the fall weather where this cotton is grown.

Procedure developed for screening for potential drought tolerance in cotton - Stoneville, MS. The levels of free proline in water stressed greenhouse grown cotton plants increased to about 100 times the concentrations found in well watered control plants. Genotypic differences were noted in proline accumulation. This suggests a possible use for this phenomena as an index for screening for drought tolerance.

Improved Fiber Quality:

Variety with improved fiber quality - Florence, SC, and Knoxville, TN. SC-1, the first commercial southeastern cotton variety to combine high lint yield with significantly improved fiber strength and elongation, was developed and released to growers in 1977. This variety should meet the demands of southeastern cotton growers for high yield and the requirements of textile manufacturers for improved fiber quality.

Improved Seed Quality:

Glandless (gossypol-free) strain released - Shafter, CA. A high yielding breeding line of glandless cotton with fiber properties equal to currently grown Acala SJ varieties was released. The presence of gossypol in current glanded varieties restricts the use of cottonseed meal primarily to feeding ruminant animals. Glandless cotton offers the potential for utilizing cottonseed as a major source of protein for feeding poultry, swine, and other livestock. Glandless cottonseed can also be used as a source of high quality protein for human consumption. Oil from glandless is of a higher quality and requires less refining.

Seed quality studies initiated - Shafter, CA, Knoxville, TN, and College Station, TX. New research projects were implemented at these locations with the objective of surveying cotton germplasm for the potential improvement of cottonseed quality. Special emphasis is being given to the goal of decreasing seed gossypol and increasing seed oil and protein. Oil, protein, and gossypol analyses have been added to the evaluation of seed from all entries in the National Regional Cotton Variety Tests.

Technological Objective 2.

New and improved cultural and management practices that optimize yield potentials, minimize production losses, preserve quality attributes, and conserve and utilize resources efficiently.

Research Locations:

7506	Auburn, Alabama
5510	Phoenix, Arizona
5206	Davis, California
5203	Shafter, California
7502	Mississippi State, Mississippi
7402	Stoneville, Mississippi
7806	Knoxville, Tennessee
7203	Brownsville, Texas
7302	College Station, Texas
7313	Lubbock, Texas

Basic Physiology:

New method developed for investigating starch metabolism in cotton leaves - Phoenix, AZ. Enzyme determinations with cotton have long suffered from the unusually large amount of polyphenolics in its leaves. This has hampered enzymatic research of biochemical metabolism. The development of a new and successful method for determination of alpha-amylase has facilitated the investigation of starch metabolism in cotton leaves.

Research on rate of photosynthesis in cotton - Phoenix, AZ. Rate of photosynthesis was shown to have a marked effect on yield of cotton. Research showed that photosynthesis could be increased about 20% on a leaf area basis by enriching the atmosphere with CO₂ to about 650 ppm. This higher rate of photosynthesis more than doubled the yield per plant. Although CO₂ enrichment may not be practical in the field, the results indicate that the relatively large yield increases can result from modest increases in rate of photosynthesis that may be accomplished by other means, such as cultural practices and genetic selection.

Cotton Diseases:

Fusarium wilt resistance of elite breeding lines and cultivars evaluated - Auburn, AL. Material submitted by 19 cooperators (3 Federal, 7 State, and 9 private) were tested. These results provide the basis for public and private commercial breeders to develop commercial varieties with increased Fusarium wilt resistance.

Verticillium wilt fungus detected in virgin lands of the West - Davis, CA. It was demonstrated that Russian thistle is susceptible to strains of the Verticillium wilt fungus that attack cotton. These results have far-reaching significance in regard to the dissemination and spread of this fungus, since Russian thistle is a tumble weed capable of disseminating infected plant parts and seed over large areas, including previously uncultivated land. The detection of both mild and severe cotton strains of the Verticillium wilt fungus in these areas show that these strains were present before cotton was planted. These results indicate that the severe cotton strain (T-1) did not develop as a result of planting cotton cultivars such as Acala 4-42-77 with a high level of tolerance to the mild strain (SS-4).

Melanin synthesis studied in soil borne fungal pathogens - College Station, TX. Fungi that cause root rots and wilts of plants usually survive in soils as resting cells that have thick walls coated with black pigments (melanins). Albino mutants lacking these pigments were used to show that melanins are vital for resistant to dessication, resistance to ultraviolet irradiation, and survival in natural soils. These studies indicate that the life cycle of many pathogenetic fungi would be disrupted by interference with the normal synthesis of melanin. Studies of the biochemical pathways for the synthesis of melanin have identified intermediate chemicals. These studies should facilitate the development of chemicals that interfere with the melanin formation process.

Improved Cultural Practices:

Growth regulating chemicals increase efficiency of cotton production - Phoenix, AZ, and Shafter, CA. Hand and machine harvest of plots treated with a plant growth regulator PIX^(R) resulted in a 12% increase in total yield with a 15% increase in first pick (earliness) while plant heights were reduced 20%.

Late season cotton insect control - Stoneville, MS. The use of chemical plant growth retardants such as chlorflurenol and Pennwalt TD-1123 has been shown to be of benefit in suppressing late season bollworms and budworms. Drastic reductions in late season new leaves and squares was achieved with subsequent suppressions of the worm populations on the treated cotton. Bollworm egg counts were lowered by as much as 77%. Use of chemical plant growth retardants could save time, money, and chemicals by reducing the need for late season insecticide applications.

Experimental seed treatment gives good stands - Lubbock, TX. Neutralizing hydrochloric acid on delinted cottonseed with an experimental neutralizer gave germination and stands equal to or higher than the commercial neutralizer, ammonia. This material can be applied simultaneously with fungicides and insecticides, thus eliminating the separate steps and equipment used to process acid delinted seed. The experimental material consists of organic and inorganic materials which do not require registration for use.

SELECTED PUBLICATIONS

Auburn, Alabama

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National Research Program 20070

BREEDING AND PRODUCTION - TOBACCO

The mission of this National Research Program is to develop the germplasm, varieties, production practices, harvesting and curing technology needed for efficient production of good quality tobacco to meet the high levels of domestic use and export demands. Efficient production requires new varieties resistant to one or more of several diseases and insects, chemical and nonchemical pest control methods and growth regulators to minimize chemical residues on the raw product and in the environment, and labor-saving cultural and curing practices. With respect to quality and consumer use, the smoking and health issue places new demands upon Federal tobacco production research. That part of the research which is directed toward maintaining the traditional high quality for which U.S. tobacco is known worldwide includes the reduction or removal, from tobacco leaf or smoke, of any constituents found to be biologically active in certain bioassay systems. Improved genetic, cultural, harvesting and curing methods are used to produce specially-modified leaf samples. The latest analytical chemical techniques and the most commonly-used bioassay systems are employed in studies on these specially-modified samples and the smoke therefrom.

NPS Contact: E. L. Moore

PACS Contact: L. L. Jansen

Technological Objective 1.

New genetic stocks of tobacco and improved cultural, harvesting, curing, and management practices that reduce undesirable constituents and maximize quality attributes, including physical and chemical characteristics that enhance consumer use and safety.

Research Locations:

7702	Tifton, Georgia
7809	Lexington, Kentucky
1108	Beltsville, Maryland
7803	Oxford, North Carolina
7802	Raleigh, North Carolina
7805	Greeneville, Tennessee

Selected Examples of Recent Progress:

Pesticide residues studied - Beltsville, MD, Oxford, NC. A special study was conducted for the purpose of evaluating the effects of pesticide treatment on tobacco in comparison with tobaccos not treated with any pesticides. Experimental tobacco samples were produced on Prince Edward Island, Canada, in an environment where contamination from soil, water, or air is expected to be minimal. The tobacco leaf samples were analyzed for 35 components and 28 pesticide residues. Preliminary results from both long- and short-term bioassay tests show only slight differences between responses in the treated and untreated samples.

Reducing residues of the sucker control chemical, maleic hydrazide (MH)-Raleigh, NC. MH sprays directed toward the leaf axillary region of the tobacco plant resulted in good sucker control with 30 percent less residues than sprays applied generally to leaves of the top half of the plant. A rate residue curve for MH was established indicating residues on the cured leaf increased directly in proportion to the amount of MH applied. Consequently, this rate residue curve may be used to determine approximately any unknown amount of the chemical that was applied in the field. Also, a study on the bound and unbound MH showed that 70 to 75 percent of the MH residues from the upper portions of the plant could be removed with water or a mixture of equal parts of water and alcohol. The effects on leaf quality of removing MH residues in this manner have not been determined.

Homogenized leaf curing (HLC) process improved - Lexington, KY, Oxford, NC, Beltsville, MD. A pilot plant was assembled and placed in operation at Oxford to produce HLC tobacco of the flue-cured, or bright, type. The mechanical aspects of the system worked extremely well, processing 4,536 kg of harvested leaf (fresh weight) per day. However, dehydration by double drum drying was much slower than anticipated, producing only about 91 kg (dry weight) on a daily basis. In further tests it was found that the HLC process appeared to influence quality less in burley tobacco than in flue-cured type tobacco. It resulted in reductions in certain components important in smoke flavor, such as solanesol and neophytadiene below levels found in normally flue-cured leaf. Reductions of these compounds were less in HLC burley as compared to normally air-cured burley. Also, four isomers of a major flavor constituent were characterized in HLC burley. HLC tobacco produced smoke that is less active in some bioassay systems. About 3,200 kg of experimental HLC tobacco were produced for the manufacture of cigarettes and evaluation of smoke chemistry and bioassay.

Short-term bioassay studies - Beltsville, MD. In short-term bioassay studies using the sebaceous gland suppression technique, leaf samples treated with maleic hydrazide at the excessively-high rate of 1000 ppm showed no difference in biologic activity from leaf from hand-suckered plants. In a similar test, homogenized cured leaf showed significantly lower activity than the standard flue-cured control. Also, in burley tobacco, leaf from the top of the plant showed more activity than leaf from the bottom of the plant, but additional confirming studies need to be carried out.

Association between leaf characteristics, smoke components, and biological responses - Beltsville, MD and Oxford, NC. A comprehensive study was completed examining simple correlations and multiple regressions among leaf characteristics, smoke components, and certain biological responses. Four bright tobacco cultivars, each with leaves from eight stalk positions, were used. A total of 151 variables were investigated, including 102 leaf and agronomic characteristics, 42 cigarette and smoke components, and seven biological responses. The results clearly indicated that certain leaf characteristics can be used as markers to predict total smoke delivery for individual smoke components. These findings demonstrated that modification of these markers through genetic, cultural, or curing manipulations may lead to the development of leaf tobacco of more desirable quality and usability.

Protein extraction from flue-cured tobacco - Oxford, NC. It was found that simple gravity sedimentation could be substituted for centrifugation in removing the chlorophyll protein fractions of the HLC sample. A total of 3,175 kg of HLC was produced and protein was extracted from 907 kg of this material. Protein yields were disappointingly low, only about 4 percent of the dry weight, indicating that the tobacco processed during the season was overmature for best yields of protein. Also, the protein obtained was contaminated with varying amounts of carbohydrates and phenolics. The protein extraction system needs to be further refined for the extraction of Fraction-1-protein (F-1-P) and Fraction-2 protein (F-2-P).

Protein extraction from burley tobacco - Lexington, KY. Leaf samples from a 1977 field experiment which evaluated variables such as tobacco type, virus infection, plant growth stages, and leaf stalk position were analyzed for the following chemical constituents: chlorophylls, carotenoids, total soluble proteins, non-extractable proteins, F-1-P, F-2-P, free amino acids total nitrogen, and nitrate nitrogen. All quantitative determinations were completed and data are being subjected to statistical analysis. Some significant findings are: (1) burley cultivar Ky 14 contained more F-1-P than bright tobacco, NC 95, which suggests no direct relationship between chlorophyll and F-1-P content; (2) infection with tobacco mosaic, tobacco etch, and tobacco vein mottling viruses lowered the amount of F-1-P; (3) tobacco mosaic and tobacco etch lowered F-2-P but infection with tobacco vein mottling virus resulted in an increase in F-2-P; and (4) the accumulation of F-1-P during plant growth followed a nonlinear pattern.

Soluble protein extraction and nutrition tests - Beltsville, MD. F-1-P in chemically-pure form was separated from chlorophyll in the chloroplasts of tobacco leaves in the approximate ratio of 8 to 1. The remaining soluble proteins were precipitated in unfractionated leaf protein (ULP) which includes F-2-P. The amino acid composition of both F-1-P and ULP are similar to the amino acid balance in the standard reference protein of the Food and Agriculture Organization of the United Nations. Preliminary nutrition tests also indicate high nutritional value for both the F-1-P and ULP as based on the protein efficiency ratio. Larger amounts of protein are being extracted for additional chemical and nutritional evaluation studies.

Complete chemical analyses of HLC samples from 1976 - Lexington, KY. Agronomic variables (variety, fertility, maturity, population density, and type of harvest) had a significant effect on the chemical components of HLC burley tobacco. The effects were similar to those in conventionally air-cured tobacco. The HLC processed tobacco was slightly lower in sugars and nitrate than the air-cured controls and generally contained only about 70 percent as much total alkaloids. High plant populations resulted in very low levels of petroleum ether extracts. Date of harvest had a much greater effect when all leaves were removed in one priming than when several primings were used. For the processing variables, only incubation duration and dewatering (the extent to which the water can be removed from the pulp and the proportion of total protein that can be extracted as soluble protein free of nonprotein solids) affected chemical composition. The results indicate that tolerances on processing variables are not critical within the range of conditions in these studies.

Leaf diseases affect chemistry and quality - Beltsville, MD and Oxford, NC. The frog-eye disease was found to influence chemistry of leaf and resulting smoke. Infected leaves were higher in total nitrogen and insoluble nitrogen, but lower in nicotine, nor-nicotine, and alpha amino nitrogen than sound leaf. Cigarettes made from frog-eye-infected leaf, when smoked, produced less tar per cigarette than cigarettes made from non-infected tobacco. However, due to decreases in number of puffs and lighter weight of tobacco, more tar was produced per gram of infected tobacco smoked. Inoculation of Maryland type tobacco varieties with the etch virus resulted in a considerable reduction in yield and quality in comparison with the non-inoculated series.

Tar/nicotine ratio - Oxford, NC. Research to develop tobacco breeding lines with a lower ratio of tar to nicotine includes hybridizing Nicotiana tabacum (cultivated tobacco) with N. rustica, a high nicotine-producing species. Recrossing hybrid material (back crossing) with the N. rustica parent has resulted in a chromosome substitution which should contain the genetic factors for nicotine production. Further tests are being conducted to determine if the genes responsible for nicotine production in N. rustica and N. tabacum are the same.

Polyphenol content of flue-cured tobacco varieties - Oxford, NC. The total polyphenol content of currently-grown flue-cured tobacco varieties was studied during 1975 and 1976. Leaf samples were taken from official variety tests conducted at one location each in Virginia, South Carolina, and Georgia, and at four locations in North Carolina. Data for both years were analyzed separately and on a combined basis. The means for 1975 and 1976 were 3.55 and 4.29 percent, respectively, on a dry weight basis. Polyphenols varied by location from 2.86 to 4.46 percent in 1975 and from 3.44 to 4.29 percent in 1976. Total polyphenol content was lowest in leaf from the bottom of the stalk and highest in leaf from the top, varying in 1975 from 2.86 to 4.39 percent and in 1976 from 3.67 to 4.63 percent. The levels of total phenols for 14 varieties varied from 3.05 to 4.05 percent in 1975 and from 4.05 to 4.66 percent in 1976. In the combined analyses differences among locations, years, varieties and stalk positions were highly significant. However, it is interesting to note that the differences among locations tended to be equal to or greater than the differences among varieties. In general, the relatively narrow range in variability of currently-grown varieties with respect to polyphenol content suggests a relatively narrow genetic base.

Total phenol content of exotic tobacco germplasm - Oxford, NC. In other research at Oxford, NC, 1,500 tobacco introductions and varieties were analyzed for total phenols. The values for tobacco introductions ranged from 1.2 to 6 percent. The values for varieties ranged from 0.2 to 4.8 percent. It is noteworthy that the polyphenol content was considerably lower in most varieties and tobacco introductions of this exotic group of tobacco strains than in commercial cultivars.

Evidence of genetic influence on polynuclear aromatic hydrocarbons in smoke - Oxford, NC and Athens, GA. Five sets of tobacco cultivars were evaluated for polynuclear aromatic hydrocarbon production (PAH). Each set contained the normal green parent and two pale yellow selections. In general, the selections containing the genetically-controlled pale yellow character produced about 10 to 30 percent lower levels of PAH in the smoke than the normal green lines. This decrease in PAH is considered important since it is believed that the PAH contributes to the biological activity of the smoke. Also, the pale yellow tobaccos generally contain lower levels of solanesol and sterols and higher levels of neophytadiene, docosanol, and fatty acids than their normal green counterparts.

Pigment levels and chemical composition - Oxford, NC. Flue-cured tobacco was generally higher in levels of plastid pigments and polyphenols than was burley tobacco. Pale yellow showed a rapid decline in chlorophyll content at maturity whereas yellow-green tobacco showed chlorophyll deficiency throughout growth. The polyphenol content was similar in the yellow and the green genotypes. Polyphenols are precursors of substances in tobacco smoke that are tumor promoters in animal systems. Burley tobacco contained lower levels of polyphenols than flue-cured tobacco as well as lower activities of polyphenoloxidase and peroxidase enzymes. In vitro experiments with ^{14}C labelled chlorophyll demonstrated that amino acids were formed from chlorophyll degradation. Plastid pigments, polyphenol, isoprenoid, and amino content in tobacco leaves are all influenced by genetic traits as well as cultural practices. The evidence suggests that potential health hazards generated by these components could be controlled by manipulation of genetic and environmental variables.

Varying chemical constituents by new production practices and varieties - Lexington, KY. Total carbonyls and total phenols were compared in tobacco materials produced by different curing and production practices for health-related studies. Recent results in cooperating laboratories showed that phenol levels in some tobacco materials correlated positively with some adverse biological effects in the derived smoke. These materials had not been studied for carbonyls, however. In the current investigation carbonyl levels were decreased in tobacco that was either grown at a higher than normal plant population density, harvested from successively higher leaf positions on the stalk, reconstituted into tobacco sheets, or air-cured. In addition, phenolic levels were decreased in tobacco that was either grown at a higher than normal plant population density, harvested from successively lower leaf positions on the stalk, reconstituted into tobacco sheets, treated to remove soluble protein, or air-cured. Total carbonyls, free amino acids, total protein and alkaloid concentrations were compared in bulk-cured and conventionally air-cured burley tobacco. The tobacco was grown with conventional and modified spacing. Significant concentration differences were found for total carbonyls, amino acids, proteins and alkaloids in lamina and midveins of leaves from plants grown with variable spacing parameters and cured by the two methods. The differences were assessed in terms of their effects upon the quality and usability of the cured tobacco. Production, cultural, genetic and agronomic parameters that caused reductions of proteins, amino acids, and alkaloids in the cured tobacco were considered favorable for achieving health-related goals.

Analytical methods - Lexington, KY. Analytical methods were partially developed for the separation and quantitative determination of lignin precursors related to hydroxycinnamic acids, aldehydes and alcohols by high-speed chromatography. Congeners of hydroxycinnamic acids were suspect as toxic agents in natural products that were inhaled directly or in smoke; these compounds are also believed to be precursors of lignin in all higher plants. The carboxylic acids, aldehydes and alcohols were separated on a reversed-phase uBondapak C₁₈ column with a methanol/water mobile phase containing 1 percent acetic acid as an ion suppressor. A 254 nm detector was used. Nonogram to microgram amounts of the compounds were analyzed by procedures that required less than 40 minutes for the chromatographic runs. Several of the alcohol precursors were synthesized by reduction of the corresponding acids with combinations of sodium. A high-speed liquid chromatographic procedure was partially developed for the separation and quantitative determination of modified nucleic acid bases and nucleosides that have cytokinin activity.

Inhibition of chemically mediated plant tumors - Lexington, KY. The hybrid of two Nicotiana species, N. suaveolens X N. langsdorfii, produces tumors spontaneously on stalks, leaf petioles, mid-ribs, and veins, but only when plants are mature. Identical tumors have been produced on young seedlings of the hybrid either by application of an aqueous solution of molecular oxygen, alone or in combination with pyrogallol or 6-azauracil. The latter two chemicals require oxygen to be biologically active. In further research these chemically mediated tumors have been strongly inhibited with ascorbic acid and dinitrophenol, two compounds which affect cellular respiration.

Effect of number of harvests on yield and quality - Tifton, GA. Reducing the number of primings from the conventional seven to as few as three in harvesting the tobacco crop had little or no adverse effect on yield, price, and value, and certain chemical constituents of the cured leaf such as total nitrogen, total alkaloids, reducing sugars, and starch. Average yields ranged from 3,395 kg/ha where three primings were used to 3,475 kg/ha with six primings, indicating no significant differences in yield. Tobacco harvested in three primings however, had the highest percentage of cured leaf with lemon color while tobacco harvested in four primings had the highest percentage of cured leaf with orange color. These two leaf colors are highly desirable. On the other hand, tobacco harvested in seven primings had the highest percentage of variegated colors which is undesirable. Tobacco from each priming treatment was graded usable by at least one or more of the six evaluating companies with the highest average percentage selected from the tobacco harvested in four primings. The results strongly indicate that the tobacco crop may be harvested without loss of quality in as few as three or four primings rather than the usual six or seven, thereby reducing the number of trips over the field and consequently reducing the cost and energy requirements of harvesting the crop.

Technological Objective 2.

New and improved genetic populations, breeding lines and varieties of tobacco that combine high yield potentials, better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, curing, harvesting, and handling to minimize production losses, and use scarce resources efficiently.

Research Locations:

7702 Tifton, Georgia
7809 Lexington, Kentucky
1108 Beltsville, Maryland (Tobacco Laboratory)
1109 Beltsville, Maryland (Plant Growth & Regulators Laboratory)
7803 Oxford, North Carolina
7802 Raleigh, North Carolina
7805 Greeneville, Tennessee

Selected Examples of Recent Progress:

Directed spray for sucker control to reduce chemical residues - Raleigh, NC. Restricting spray coverage to the general site of sucker growth through directed spray coverage is a potential means of reducing growth regulator residues. In tests during 1977, very hot and dry conditions during the treatment period at all locations reduced effectiveness. Even so, experimental compound CGA-41065 resulted in excellent sucker control. Samples were collected for residue determinations. Fan nozzles at low pressure were found to be the best for applying the largest amount of fatty alcohol spray solution down the tobacco plant stem with a minimum of wetting on leaf surfaces. The dripless nozzles were not suited for use in directed sprays.

Regional evaluation of tobacco sucker control chemicals - Beltsville, MD; Tifton, GA; Raleigh, NC; and Greeneville, TN. The ad hoc Regional Tobacco Growth Regulator Committee (TGRC) evaluated CGA-41065 and a tank mix of C₁₀ alcohol plus the potassium salt of maleic hydrazide (KMH) in an advanced test. CGA-41065 was the most effective agent compared to the check of fatty alcohol followed by MH. Based upon agronomic parameters, CGA-41065 and the fatty alcohol-KMH tank mix were approved by the TGRC as being effective sucker control agents. In addition the Committee evaluated RC-7701, ARD-1635, and ARD-1680 in a preliminary test. RC-7701 did not control suckers as well as MH. The ARD materials used as adjuvants with 1/2 rates of MH did not enhance effectiveness of MH when compared to the 1/2 rate of MH as a control. CGA-41065 was found to be more effective in controlling sucker growth on field-grown tobacco plants than MH, with no evidence of leaf injury. In sequential treatment with fatty alcohol (OST-85), compound CGA-41065 controlled 95 percent of the sucker growth over a 10-week period, while MH-30 used in a similar manner controlled 90 percent of the suckers. The yield of cured leaf also increased with the increase in sucker control.

Residual effects of a sucker control chemical - Raleigh, NC. For the third successive year test data confirmed that the dinitroaniline-type suckering agents will affect germination and growth of winter cover crops following

tobacco. Although the dinitroanilines have been registered for use, results showed that most tobacco growers could not use these materials for tobacco sucker control because of their effects on other crops in rotations.

Nitrogen fertilization and sucker control - Raleigh, NC. In studying the influence of nitrogen rate on sucker growth and control it was found that at normal rates of nitrogen sucker control was improved with increased concentrations of MH and also with two applications of MH. At these levels of MH sucker control decreased when 20 lb/A of nitrogen was applied above the normal rate. Thus, increased rates of nitrogen required increased rates of MH to provide adequate sucker control. These results demonstrate the grower's need for higher rates of MH to control suckers when they maximize yields with increased rates of nitrogen.

Seed germination and seedling uniformity - Raleigh, NC. In tobacco seed germination tests individual seed coats cracked at different intervals varying from 2 to 4 days after seeding. The most uniform seedling populations came from those seeds where the seed coats cracked after 3 days, and the least uniform from seed lots where the seed coats cracked after 4 days. Seedlings carefully selected for uniformity from the 3-day group grew uniformly until plant competition occurred. Seed from different portions of the seed capsule--that is, top, middle, or bottom--germinated at different rates. Seed from the top third of the capsule were slower and resulted in greater transplant variability. Seed from a lot separated into different sizes of seeds showed that the large, although not the largest, seeds had the best germination. Mitotic chromosome figures indicating cell division were found in embryos 56 hr. after beginning of the germination test.

Basic and applied research to control tobacco suckers - Plant Hormone and Regulators Laboratory, Beltsville, MD. Basic research in tobacco growth regulators has as its objective the isolation and identification of new growth regulators from higher plant material. Camptothecin was isolated (from Camptotheca acuminata) in sufficient quantities for small field trials using several different formulations for application. In addition, a gel permeation chromatographic procedure has been developed to produce sufficient harringtonolide extracted from Cephalotaxus harringtonii for greenhouse studies. Also, the inhibitory compounds present in Ailanthus altissima and Sesbania punicea have been isolated. As part of the applied research natural and synthetic plant growth regulators and combinations were evaluated for the control of tobacco sucker growth. Camptothecin effectively controlled axillary bud growth or suckers on field-grown tobacco when applied to buds in a lanolin paste. It was less effective as a spray and when combined with other carriers. Attempts to obtain sucker control were not successful in field-grown tobacco using low levels of MH combined with certain other growth regulators, including abscisic acid, chloulurenol, naphthacetic acid, beta naphthacetic acid, and daminozide. On the other hand, maleic hydrazide at 75 mg/plant plus CGA-41065 at 10 mg/plant resulted in nearly 100 percent control of suckers. Other chemicals were evaluated for their potential as sucker control agents on greenhouse and field-grown plants.

Two sodium compounds damaged leaf but not suckers - Plant Hormone and Regulators Laboratory, Beltsville, MD. Uptake of growth inhibitors by tobacco roots was investigated. Solutions of two metabolic inhibitors, sodium cyanide and sodium arsenite, were injected into soil and tested for growth inhibition of axillary shoots or tobacco suckers. Both inhibitors were rapidly taken up by the roots, translocated, and accumulated in the leaves. Leaf damage was severe but axillary bud or sucker growth was not controlled.

Chemical yellowing of burley tobacco - Greeneville, TN and Lexington, KY. Burley tobacco treated with 150 mg/plant of ethephon 4 days prior to harvest completed the 6-week air-curing cycle 10 days earlier than non-treated tobacco. Yields at four locations were reduced about 10 percent when ethephon was applied 4 days before harvest.

Chemical ripening or yellowing leaf - Tifton, GA. - An application of the ethylene-releasing agent, ethephon, at 2 liters per 7,000 plants directed over the four to five lower leaves of the tobacco plant prior to the second priming was effective in "yellowing" only the treated leaves in about 60 hours, without affecting the upper plant leaves. The curing time of the yellowed leaves was reduced by one-third. However, injecting ethelene gas directly into the curing barn soon after the curing cycle began failed to improve leaf color or change curing time significantly.

Fertilization affects yield - Greeneville, TN. Increasing phosphorous and potassium above recommended rates during dry weather in Tennessee improved yields of burley tobacco, but increased nitrogen rates decreased yields. Also, doubling the phosphorous rates from 150 to 300 lbs/A resulted in a corresponding increase in seed production of variety Burley 64, a poor seed producer.

Improved transplant production - Tifton, GA. Use of plastic seedbed covers instead of cheesecloth resulted in a reduction of fertilizer requirements, rate of seeding, and growing time for transplants. Reductions were 30 to 50 percent in each category. Also, clipping away part of the tallest leaf from the largest seedlings with a rotary mower prior to transplanting improved seedling uniformity and increased percentage of plants suitable for transplanting. Clipped plants had firmer stems, better root systems, and made faster recovery in the field. Moderate clipping had no adverse effect on yield, value, and chemical properties of the cured leaf. On the other hand, severe clipping did reduce yields.

Light indifferent seeds increase germination and seedling survival - Lexington, KY. In direct field seeding experiments with burley tobacco higher germination and survival of seedlings was obtained with light-indifferent than with light-requiring seeds. Light-indifferent seeds germinate in the dark as well as in the light, while light-requiring seeds will germinate only in the presence of light. Best results were obtained with light-indifferent seeds covered with a 5 mm layer of vermiculite held in place by finely sprayed asphalt.

Storage and drying of HLC homogenate - Oxford, NC. Prolonged storage of the homogenate, for later drying, is important in the homogenized leaf curing process. Incubation for 24 hours in sealed containers exhausted oxygen from the system. Previous evidence had shown that absence of oxygen (anaerobic conditions) aided in the preservation of homogenized leaf for an extended period of time. This information is important in improving the efficiency of HLC. It was also found that double-drum drying is more effective than vacuum drying or fluidized bed drying. Tobacco is dried in a thin sheet form that, with the addition of suitable binders, can be made directly into reconstituted sheet suitable for the manufacture of tobacco products. Furthermore, losses of reducing sugars were considerably less than with the vacuum drying method. One ton of HLC from flue-cured type tobacco containing stalk, mid-rib, and leaf lamina was produced for evaluation of chemical and biologic properties. NCI is cooperating in evaluation of biologic properties.

Genetics and breeding - Oxford, NC. Ten advanced breeding lines have been developed and put into state and regional tests for 1978. All of these possess resistance to black shank and bacterial wilt and five also possess resistance to root knot nematodes. Over 110 breeding lines with mosaic resistance were screened, selected, and selfed or back-crossed. Segregating material for the symptomless mosaic reaction was evaluated and selection and back-crossing carried out. Thirty-eight breeding lines with resistance to PVY were evaluated for agronomic and chemical characteristics. Three studies for breeding procedures designed to improve brown spot resistance involved mass selection, recurrent selection, and pedigree selection.

Insect resistance - Oxford, NC and Tifton, GA. Tobacco Introduction 1112 was found to be resistant to the tobacco budworm, and this apparent resistance was verified at Tifton, Georgia. Evidence obtained at Oxford indicates that resistance is due to oviposition nonpreference and that the absence of glands on the foliar trichome of TI 1112 may be responsible. A genetic study showed that the absence of the glands on trichomes was controlled by a single recessive gene. The first generation (F_1) between a glanded and glandless type either has no glands or small glands. Twenty-two selected strains were tested in greenhouse chambers in 1977 for insect resistance. Significant differences were found among the entries in budworm survival and these results were also verified in field tests. Twenty-six entries were tested at Tifton, Georgia, where budworms and hornworms build to high levels of infestation, and in these tests significant differences in insect damage were obtained among entries. A dihaploid entry (No. 35), obtained by the anther culture of a hybrid between a budworm resistant tobacco introduction (1112) and a standard tobacco variety was found to be almost completely free of hornworm damage. A mutation is suspected because neither parent was resistant to this insect pest. Genetic studies will be conducted to determine the inheritance of hornworm resistance in line No. 35.

Genetic control of sucker production - Oxford, NC. In studies designed to measure the genetic influence on sucker production, 16 flue-cured tobacco cultivars were evaluated at two locations over 2 years and found to vary significantly in both number and weight of suckers produced per pound. In another genetic population, sucker production was found to vary from

less than 100 grams to over 600 grams per plant. Genetic control of reduced sucker production could result in a lessened need for chemical sucker control.

A chemical marker for cytoplasmic function in species hybrids - Oxford, NC. Total inheritance in plants is a function of the cell nucleus and the surrounding cytoplasm. The part played by the nucleus and its constituent chromosomes is well established but the function of the cytoplasm, although known to be important in inheritance, is poorly understood. It was determined that 10 Nicotiana species including cultivated tobacco (N. tabacum) are "Insensitive" to Tentoxin, a cyclic tetrapeptide. The remaining 50 species are "Sensitive". Sensitivity to Tentoxin is a cytoplasmic response and can be used as a means of identifying and studying the influence of cytoplasm in interspecific crosses of the sensitive species with N. tabacum.

Cytoplasmic male sterility and restoration of fertility - Oxford, NC. In the transfer of resistance to such diseases as fungal and bacterial leaf spots and root knot from N. repanda into cultivated tobacco, N. tabacum, it was necessary to use N. repanda as the maternal cytoplasmic parent. Repeated pollinations of the derived hybrid with pollen of N. tabacum led to displacement of the N. repanda chromosomes by those of the recurrent N. tabacum parent. The presence of N. tabacum chromosomes in the maternal (N. repanda) cytoplasm resulted in distorted anthers, nonfunctional pollen, and male sterility. When such male sterile plants were pollinated with pollen from a restorer line containing a specific chromosome fragment from N. repanda, the resulting progeny had normal flowers and produced normal pollen. Plants with restored fertility can be used to pollinate male sterile N. tabacum to produce a generation that contains N. tabacum cytoplasm rather than that of N. repanda. Subsequent selection of plants with disease resistance permits continued disease resistance breeding without the obstacle of male sterility.

Dihaploids in breeding for resistance to viruses - Oxford, NC. A group of flue-cured dihaploids that was susceptible to tobacco mosaic virus (TMV) but resistant to potato virus Y (PVY) produced the highest yield of cured leaf per hectare (3,064 kg). This was greater than the yield of a group that was resistant to TMV but susceptible to PVY (2,874 kg) or the group that was susceptible to both diseases (2,914 kg). The yield of the group with resistance to both diseases was significantly less than the other three groups (2,680 kg). Four dihaploids among the 132 entries tested had significantly higher values than the mid-parent value. Three of the superior dihaploids came from the group that was susceptible to TMV but resistant to PVY and the fourth came from the group that was resistant to both viruses. These findings support earlier evidence from conventional breeding techniques that the presence of the factor for resistance to TMV is generally associated with reduced yield and quality in flue-cured tobacco. The fact that one of the high yielding selections had resistance to TMV indicates that there can be exceptions to the general rule.

Some chemical differences between pale yellow and normal green tobacco - Oxford, NC. In attempts to determine why pale yellow flue-cured tobacco is significantly lower in total reducing sugars than normal green tobacco, harvests were made from four stalk positions from a pale yellow and a normal green cultivar. For each stalk position, harvests were made 3, 2,

1, and 0 weeks prior to what would be considered the normal time to harvest. Based on the reducing sugars and starch content, it appears that pale yellow tobacco should be harvested 1 to 2 weeks earlier than it has been harvested in previous years. However, it does not appear that the level of sugars in pale yellow lines ever reach those in normal green varieties. Several physiological mechanisms and enzymatic systems appear to be different in pale yellow lines from those in green cultivars.

Antagonism between fungi in biocontrol of a leaf spot disease - Oxford, NC. The fungus Cladosporium cladosporoides was consistently second to Alternaria spp. in frequency as an internal parasite (endophyte) of healthy leaf tissues of several plants including grape, privet, sweet gum, sycamore, tomato, corn, tobacco, squash, soybeans, and peanuts in North Carolina. Because of its ubiquity and its antagonism to pathogenic Alternaria, the parasitism of healthy tobacco leaves by C. cladosporoides was studied. Conidia from 10-day old, V-8 agar cultures were added to water and sprayed on tobacco leaves or drops of the aqueous solution were placed on the leaf surfaces. Germination of the conidia and parasitism of tobacco leaves was favored by a temperature of 21°C and high humidity. The wetting agent, Tween-80, stimulated the rate of conidia germination and growth. Germination was 50 percent in water and 100 percent in 0.1% Tween in 24 hours. Both stomatal and direct penetration of the tobacco leaf tissue were observed and some conidia passed through the stomata during inoculation and germinated in the sub-stomatal cavity. Mycellium grew on the leaf surface as well as in the epidermal and mesophyll tissues of the leaves. No symptoms were associated with the parasitism of the leaves under the experimental conditions. Conidia were produced on the leaf surface 3 to 7 days after inoculation. Thus, C. cladosporoides is a common, easily-established, endophytic parasite of tobacco leaves with a short life cycle and may be of considerable value as an antagonist to leaf pathogens.

Control of brownspot by tobacco leaf microflora - Oxford, NC. Tobacco leaf microflora appeared to reduce infection by the brownspot pathogen, Alternaria alternata. Disinfection of the leaf's surface with ethanol, which reduced microflora populations 50 percent, prior to inoculation with the brownspot pathogen, resulted consistently in higher levels of infection. Also, nonpathogenic isolates of Alternaria applied to tobacco leaves before inoculation with the brownspot pathogen reduced development of the brownspot disease. Disease severity was reduced 60 percent in the laboratory and 65 percent in artificially-induced infections. The pathogen was reduced to epiphytic growth on the leaf surface in the presence of germinated non-pathogenic conidia.

Increased bacterial barn rot in bulk-curing barns - Oxford, NC. Bacterial barn rot, a soft rot of tobacco leaf in curing barns, has increased, and in 1976 ranked fourth in importance among major tobacco diseases. The increase in severity is associated with a shift from use of conventional flue-curing barns to large bulk-curing barns in which leaf is more closely packed and aeration is diminished. Erwinia carotovora, the common soft rot bacterium, and a related species, E. chrysanthemi, have been identified as the pathogens.

Antagonism between bacteria and a fungus in leaf spot control - Oxford, NC. Sixteen bacterial isolates, primarily from tobacco leaf surfaces were screened in vitro for effects on spore germination and germ tube development of three Alternaria isolates. Most bacterial isolates suppressed number of germ tubes, and length and branching of the longest germ tube. Bacterial isolates that were most inhibitory to growth of A. alternata in vitro also were most inhibitory to that fungus on leaf surfaces. Using this in vitro system, five bacterial isolates were selected for foliar biocontrol studies. One isolate, Bacillus cereus subsp. Mycoides effectively controlled tobacco brownspot (Alternaria alternata) lesion development in a controlled environment. Microscopic observations of the leaf surface showed conidial germination was 10 percent in the presence of B. cereus subsp. Mycoides whereas 98 percent germinated in the control and produced brownspot symptoms. Several bacterial isolates from soft rotted tobacco in the curing barn were identified and characterized. This was facilitated by the development of a bacteriological key (in cooperation with Dr. E. Echandi, NCSU). The losses to growers caused by soft rot in the curing barn were estimated at \$31.6 million in 1976. A bacteriocin capable of controlling one of the pathogenic species causing barn rot was isolated by Dr. E. Echandi.

Effects of fertilizer on disease incidence in black shank - Oxford, NC. Studies to determine the reasons for continued high losses to black shank disease even in resistant varieties showed that increased amounts of 15-0-15 fertilizer applied as a side dressing after transplanting increased incidence of the disease in moderate and highly-resistant varieties. Twice the normal amount of fertilizer slightly increased the mortality but four times the normal amount caused a significant increase in the number of diseased plants.

Performance of varieties in close spacing - Oxford, NC. Studies on the performance of tobacco varieties in close-grown culture showed that Kutsaga Mammoth and Coker-187-Mammoth gave the highest yields in the close-grown system. The highest-yielding, normal-flowering cultivar was Oxford 26, an old bacterial wilt resistant variety. Oxford 26 also had the best smoking quality of any of the close-grown cultivars. Chemical analyses of the leaf are not complete.

Techniques to improve haploid plantlet production - Oxford, NC. Efforts to improve haploid plantlet production from anthers met with some success. Storage of anthers at room temperatures 4 to 12 hours prior to plating on an agar medium was found to increase the number of plantlets. Modification of an existing medium formulation by adding 20 percent more sugar and increasing myoinositol from 100 to 300 mg per liter also aided in the production of more plantlets. In addition, the quantity of agar was decreased from 6 grams per liter to 4 grams. The softer agar tends to hold the plantlets firmly in place and increase the number of plantlets. The combination of pre-storage treatment and medium modification resulted in an increase in plantlets from 2,500 to 3,000 per month. Currently the limiting factor in adapting the haploid method to general breeding practice is greenhouse space necessary for identifying colchicine-induced dihaploids and increasing seeds.

Breeding and genetics of burley and dark tobacco - Lexington, KY. Advanced breeding lines of burley tobacco having the potential for high yield and quality and combined resistances to four major tobacco diseases were grown in replicated plots at 14 locations on black root-rot infested soil and at two locations on disease-free soil. Six other lines with resistance to five diseases were grown at five locations on black shank infested soil. Two of the lines were evaluated in a four-state regional variety test. Advanced lines of dark air-cured and fire-cured tobacco were grown in replicated plots and evaluated for air and fire-curing characteristics, quality, yielding ability and chemical composition. Work was continued on the transfer of low alkaloid genes into dark air-cured and fire-cured tobacco varietal backgrounds.

Relationships between disease resistance and other plant characters - Lexington, Ky. Studies with near isogenic lines for responses to each of four diseases, black root rot, black shank, tobacco mosaic, and wildfire, indicated a general lack of relationship between single disease resistance and other traits measured. Also, combinations of two resistances did not produce lines that differed from the susceptible parents. During the past year, the first cross and selection cycle was conducted to develop lines with three resistances. The ultimate objective is to compare susceptible lines, single-resistant lines, and multiple resistant lines.

Inheritance of reaction to tobacco vein mottling virus and tobacco etch virus - Lexington, KY. Seven cultivars and all possible crosses among them were evaluated for reaction to the tobacco vein mottling virus. The cultivars (Ky 10, Ky 12, Ky 14, Ky 41A, and Ky 16) were not significantly different and averaged 1.5 on a rating scale of 0-5. Burley 37 and Burley 49 were more susceptible and were rated at 3.0. Distribution of the hybrids tended to follow the common parent with hybrids involving Burley 37 being the most susceptible. Resistance was incompletely dominant. Crosses between TI 1406 and burley varieties indicated that resistance to the etch virus in TI 1406 is recessive under Kentucky conditions. All F₁ hybrids between TI 1406 and burley varieties were susceptible.

Short internode burley tobacco mutant - Lexington, KY. Short and normal internode plants with the same genetic background were studied to determine whether the short internode character was constant or differed with growth environment. Self- and reciprocally-grafted plants were grown in the field, greenhouse, and controlled environments. In each environment control of internode length was localized in the shoot. The degree of internode length suppression differed between growth environments. Suppression was greater in the field than under greenhouse glass which filtered out much of the UV light. In controlled environments both lines responded to red and far-red terminal radiation indicating function of the phytochrome system. Warmer temperatures correlated with longer internodes in both lines. Extended daily photosynthetic periods removed most of the internode length differences. The environmental responses all suggest a genetic controlled difference in natural regulator balance.

Germination and seedling establishment in the field - Lexington, KY. In the field seeds were sown in rows in a plot of chemically-killed barley stubble and in a tilled plot. Emergence of seeds coated with dry Super Slurper, a hydrophilic starch compound, or mixed with wet Super Slurper and sown with a prototype fluid drill was compared with that of untreated control seeds. Germination was poor in all treatments when seeds were left uncovered. Covering the seeds with 5 mm of vermiculite or fine soil improved germination. Super Slurper did not improve seedling establishment, probably because seeding was done during an extended period of near zero rainfall. The killed stubble plots held moisture better than the tilled plots. In further tests at transplanting time, plants were removed from the bed and immediately dipped in a thick slurry of Super Slurper. Under high stress transplant conditions (high temperature and low soil moisture) 95 percent of the plants survived. New root growth occurred 3 to 5 days earlier on dipped plants than on control plants.

Effects of modified plant populations and spacings on physical and chemical characteristics - Lexington, KY. Plants that were grown in high, normal, and low density populations to determine effects of plant population and spacing on physical characteristics at the start of curing were analyzed after air cure (conventional and primed leaf) and bulk cure of primed leaves. Cured leaf samples were analyzed for total carbonyls, protein, amino acids and alkaloids. Total protein and total free amino acid concentrations at time of harvest were highest in the low populations and lowest in the high populations. Total free amino acid concentrations increased for all populations during each of the curing procedures. Highest contents of amino acids were in the lamina of primed air cured leaves and in midveins of bulk cured leaves. Total protein concentrations decreased most during conventional air curing and least during bulk curing of primed leaves. Primed leaves from the high plant population did not decrease in total protein concentration during air or bulk curing, probably because the small leaves dried before cure was complete. Alkaloid concentration in mid-stalk leaves increased during conventional air curing, but remained nearly constant during bulk curing. Total carbonyls decreased about the same amount in leaf lamina during air and bulk curing, but the decrease in midveins was greater in air-cured than in bulk-cured samples.

Greenhouse-grown tobacco for off-season experiments - Lexington, KY. Supplemental lighting from VHO cool-white fluorescent lamps was supplied to greenhouse-grown tobacco plants. These lamps emit about the same percentage of their light in the near-UV range as does sunlight. The summer greenhouse plants grew as well as the field plants, but they remained green longer and did not cure as well. In winter, plants that received supplemental light grew much more rapidly and produced a greater number of heavier leaves than did the controls without supplemental lighting. Leaves of the winter greenhouse plants ripened faster than summer greenhouse plants, but slower than summer field plants. The winter greenhouse plants were smaller and did not cure as well as summer field plants, but they are useful for preliminary, off-season studies of curing techniques. They were also suitable for extraction of Fraction-1-protein.

Enzymatic and chemical changes that occur during bulk curing of burley tobacco - Lexington, KY. Burley tobacco was bulk-cured under four different environments and sampled daily until the lamina was dry. The environments were: (1) ambient, (2) ethylene, approximately 100 ppm, (3) oxygen to raise the concentration to approximately 25 percent, and (4) nitrogen to reduce oxygen to about 15%. The same temperature and humidity were maintained in all chambers. They were: 90°F and 85 to 90 percent relative humidity for the first 3 days, 95°F and 80 to 85 percent relative humidity for the next 2 days or until the lamina was dried, then 120°F until the midribs were dry. The tobacco cured in the added oxygen chamber had characteristics of barn air-cured tobacco, good body and color. The tobacco from the added ethylene had fair body, but was too light in color. The tobacco from the other two chambers was of very poor quality. Samples are being analyzed for chemical composition. From incomplete chemical data it appears that the oxidative reaction in the chamber where oxygen was added approaches that in normally air-cured tobacco.

Resistance to budworms and hornworms - Tifton, GA and Oxford, NC. The development of budworm and hornworm resistant cultivars is an alternative to chemical means of controlling these tobacco pests. One hundred breeding lines and crosses were screened to identify resistant germplasm. This test met with considerable success. Several crosses from TI-1112, a primitive line from Venezuela, showed a high level of resistance or tolerance to budworm. Two of the crosses, entries number 24 and 35 also showed high levels of resistance to hornworm, especially entry number 35 which originated from a cross involving TI-1112 and a flue-cured, Speight G-28. Mature plants of the two entries showed little or no hornworm damage even during a period of extremely high populations (15 to 20 adult hornworms per plant) until the leaves of susceptible plants in the adjoining plots had been eaten away and no other tobacco foliage was available. This material should be useful in further breeding for development of insect resistant cultivars.

Interspecific transfer of disease resistance - Beltsville, MD. At Beltsville significant progress was made in genetics and breeding research with the objective of incorporating disease resistance from Nicotiana species and N. tabacum introductions into advanced breeding lines of the several tobacco types. Some specific examples include: (a) The transfer of resistance to the fungus leaf disease, brown spot, has been advanced by back crossing with flue-cured cultivars to the point where breeding lines of good flue-cured type have been obtained. Data obtained at Oxford, NC, and Beltsville, MD, indicated these flue-cured breeding stocks are approaching the stage when they can be used in varietal development. (b) Resistance from N. repanda to another fungus leafspot disease "frog-eye" was advanced to the 3rd backcross generation. Resistant plants are self-fertile; however, resistance is not yet genetically stable. Cytological studies will determine the number of chromosomes in cells of resistant and susceptible plants. (c) Nicotiana rustica is the source of resistance to a new virulent race of the bacterial disease, wildfire, and also to the bacterial disease, angular leaf spot. Resistance to the new race of wildfire and to blackfire has been stabilized in breeding lines of burley, Wisconsin cigar binder, and in dark fire-cured tobacco types. Toxins produced by the two races of wildfire bacteria are being studied for their potential use in the development of resistant tobacco. (d) Resistance to the root knot nematode,

Meloidogyne javanica exists in N. repanda. Much progress has been made in transferring this resistance into cultivated tobacco breeding lines. (e) Monosomic tobaccos lack one of the normal 24 pairs of chromosomes. Hence, a different pair of chromosomes is lacking in a series of 24 monosomic lines. Through monosomic analysis it was determined that a single gene conditioning root knot resistance is contained in chromosome G. This chromosome was contributed to N. tabacum from a progenitor species, N. tomentosa.

Soil sterilants and yield of black shank-resistant cultivars - Greeneville, TN. Effectiveness of chemical soil sterilants in improving yields of black shank resistant burley cultivars was influenced by source of resistance. Yield increases up to 67% for a total of 2,856 kg/ha were obtained for Burley 64, with cigar cultivar Fla 301 as a source of resistance, on soil treated with multipurpose chemicals. On the other hand, yields of hybrid Ky 14 x L8, with Nicotiana longiflora, a wild relative of tobacco as a source of resistance, were actually decreased by some chemicals.

NC 89, new multiple-disease resistant variety released - Oxford, NC, in cooperation with the North Carolina Agricultural Experiment Station. NC 89 met the rigid standards for physical and chemical characteristics of cured leaf and smoke flavor required for variety release by the five-State Flue-Cured Tobacco Variety Advisory Committee. This variety has resistance to black shank, bacterial wilt, Fusarium wilt, and the common root knot nematode (Meloidogyne incognita). In addition, it has moderate resistance to black root rot and tolerance to brown spot. NC 89 should play an important role in the control of tobacco diseases in flue-cured regions from Virginia to Florida by producing high yields of good quality tobacco.

Two new high-yielding, disease-resistant burley varieties released - Lexington, KY, in cooperation with the Kentucky Agricultural Experiment Station. Ky 15 and Ky 17 are resistant to black root rot, Fusarium wilt, wildfire, and tobacco mosaic. The exceptionally high level of black root rot resistance or immunity is from a wild relative of tobacco, Nicotiana debneyi, but was introduced into Ky 15 and Ky 17 from variety Burley 49. Ky 17 is also resistant to the two races of the causal organism of the black shank disease. Yields of both varieties were significantly more than the parent variety, Burley 49, with yields of Ky 15 slightly above those of Ky 17. Leaf quality is acceptable for industry and consumer needs.

Pennlan, a Pennsylvania cigar-filler variety released - Beltsville, MD, in cooperation with the Pennsylvania Agricultural Experiment Station. Pennlan carries the same resistance as the widely-grown Pennbel 69 to the destructive bacterial leaf disease, wildfire, and the tobacco mosaic virus. In addition, it performed well in the presence of the tobacco etch virus where all other cigar-filler type varieties were heavily infected and suffered severe losses of yield and quality. Pennlan is the first cigar-filler type variety tolerant to tobacco etch. It is well adapted to tobacco-producing areas in Pennsylvania and the Ohio Valley. It yields less than Pennbel 69 but matures earlier.

A new dark fire-cured type tobacco variety, DF-911, released - Beltsville, MD, in cooperation with the Tennessee Agricultural Experiment Station. DF-911 possesses immunity to the black root rot disease introduced into cultivated tobacco from Nicotiana debneyi. Yield and quality are similar to the moderate yields and high quality of the standard dark fire-cured tobacco, Madole.

NC PY 10, a pale yellow, flue-cured breeding line, released - Oxford, NC, in cooperation with the North Carolina Agricultural Experiment Station.

NC PY 10 produces cured leaf that equals widely-grown NC 2326 in grade index and percent nicotine. The yield and reducing sugars are slightly lower and the total nitrogen, alpha amino nitrogen, and soluble nitrogen are slightly higher than in NC 2326. These constituents are regarded as measures of quality. The line matures about 10 days earlier than normal flue-cured varieties and yellowing time in the barn is about half that required for normal varieties. The pale yellow character of the new breeding line is of interest, particularly to flue-cured tobacco breeders, because of the line's early maturity and relatively uniform ripening. These characteristics may be used to extend the harvest period in development of new varieties thereby realizing more efficient use of harvesting and curing equipment. NC PY 10 is similar to NC 2326 in days to flower, number of leaves per plant, leaf size and plant height, and is also resistant to the black shank disease.

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National Research Program 20080

BREEDING AND PRODUCTION - SOYBEANS, PEANUTS and OTHER OILSEED CROPS

This National Research Program involves research to improve agricultural production efficiency by developing new and improved plant genetic resources and cultural and management practices for soybeans, peanuts, sunflower, flax, safflower, and guar. Plant geneticists, agronomists, plant pathologists, plant physiologists, microbiologists, chemists, entomologists, and soil scientists (both Federal and State) work in a team approach to evaluate and improve oilseeds and oilseeds cultural methods.

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Technological Objective 1.

New and improved genetic populations, breeding lines, and varieties of oilseed crops that combine improved yield potentials and favored quality characters, including reduced contents of undesirable constituents, with better resistance to pests, tolerance to environmental stress, and adaptation for mechanized culture, harvesting and handling.

Research Locations:

5502	Tucson, Arizona
5206	Davis, California
7602	Gainesville, Florida
7702	Tifton, Georgia
3311	Urbana, Illinois
3302	West Lafayette, Indiana
3408	Ames, Iowa
1110	Beltsville, Maryland
1109	Beltsville, Maryland
7402	Stoneville, Mississippi
3402	Columbia, Missouri
7802	Raleigh, North Carolina
3602	Fargo, North Dakota
3307	Wooster, Ohio
7317	Stillwater, Oklahoma
3608	Brookings, South Dakota
7315	Bushland, Texas
7314	Vernon, Texas
7812	Suffolk, Virginia

Selected Examples of Recent Progress:

Soybeans:

New disease-resistant varieties for southern part of Corn Belt - Urbana, IL, in cooperation with State Experiment Stations. 'Franklin' is resistant to Race 3 of the soybean cyst nematode and has higher yield

and more resistance to shattering, lodging, and leafhopper than 'Custer,' the Group IV variety it should replace. 'Union' is a high yielding early Group IV variety with resistance to downy mildew and phytophthora root rot. Yield advantages of Franklin and Union over the varieties they replace are 2 bushels/acre for one-half million acres and 2.6 bushels/acre for 1 to 2 million acres, respectively.

Estimates of disease losses - Urbana, IL. Powdery mildew infection of an inoculated susceptible variety 'Hark' reduced seed yields and size 11 and 10 percent, respectively, as compared to benomyl treated soybeans. Reductions in yield and seed size ranged from 1 to 27 percent for brown spot inoculated and naturally infected soybeans, as compared to benomyl treated soybeans. Two distinctive lesion types of brown spot were observed: (1) Dark-brown irregular spots developed on leaves of plants with green cotyledons; and (2) Dark-brownish lesions accompanied by a yellow halo developed on leaves of plants with yellow cotyledons.

Uniform tests for Northern States provide five new varieties - West Lafayette, IN, and cooperating agencies. The Uniform Tests for Northern States provided the data for the release of five new varieties: 'Elf,' 'Franklin,' and 'Union' (described elsewhere herein) and 'Maple Arrow' and 'Crawford.' Maple Arrow is a Group 00 maturity variety for Canada; Crawford is a Group IV maturity soybean with higher yields than 'Cutler 71,' 'Kent,' or 'Columbus.'

Brown stem rot disease widespread in northern Iowa - Ames, IA. An extensive survey of soybean fields in northern Iowa indicated that 95 percent of the fields sampled contained plants with brown stem rot disease. Prevalence and severity of the disease were 38 and 35 percent, respectively.

New soybean varieties released - Beltsville, MD, in cooperation with Delaware and Maryland Agricultural Experiment Stations. 'Celest,' a new high yielding soybean with excellent seed quality and resistance to Diaporthe stem and pod blight and root-knot nematode was released in cooperation with Delaware Agricultural Experiment Station. The variety is of Group V maturity and has some tolerance to Mexican bean beetle and to drought in sandy soils. 'Miles,' released in cooperation with Maryland Agricultural Experiment Station, is a high yielding Group IV maturity soybean superior to Kent for seed quality and resistance to shattering.

Fungal and virus diseases reduce nitrogen fixation in soybeans - Beltsville, MD. The root-rot fungus *Rhizoctonia* was shown to infect nodules and to interfere with plant growth, nodulation, and the nitrogen fixation process. The seedborne Tobacco Ringspot Virus (TRSV), the cause of bud blight, was present in the nodules and reduced the nitrogen fixation rate per plant. On a nodule-weight basis, nitrogen fixation rate of TRSV infected plants decreased at prebloom, bloom, and early pod growth stages but increased during pod-fill and mature-pod stages.

New soybean varieties provide increased yields and resistances to diseases - Stoneville, MS, in cooperation with State Experiment Stations. 'Bedford' was developed specifically to provide a highly productive

variety resistant to Race 4 of the soybean cyst nematode for an area covering approximately 3 million acres in western Tennessee and Kentucky, southeastern Missouri, northeastern Arkansas, and northeastern Mississippi. The variety is also resistant to Races 1 and 3 of the cyst nematode. 'Govan' provides a productive variety with resistance to the two species of root-knot nematodes, Meloidogyne incognita and Meloidogyne arenaria, especially needed for the Coastal Plain soils of South Carolina, North Carolina, and Alabama. The variety is also well suited for production on the low-lying, slowly drained soils of the Delta. 'Dowling' gives a better adapted variety for production in the Texas Gulf Coast area.

Additional genes for resistance to Phytophthora rot - Stoneville, MS.

Two newly discovered genes and a total of four major genes for resistance to phytophthora rot were found in the variety 'Tracey.' Tracey is resistant to all nine known races of phytophthora rot. Resistance to phytophthora rot is essential to permit soybean production on the 5 million acres of low-lying, slowly drained clays of the lower Mississippi Valley.

Resistance to yeast-spot fungus discovered - Stoneville, MS. Strains resistant to the yeast-spot fungus were identified. The fungus is carried in the mouth parts of the stinkbug as it feeds upon the developing seed: with heavy stinkbug populations, seed yields are greatly reduced. Development of varieties resistant to the yeast-spot fungus will reduce the injury from stinkbug feeding.

Recurrent selection for increased protein is effective - Raleigh, NC.

Recurrent selection for seed protein concentration resulted in increased total protein production per unit area. Both seed yield and protein concentration of the seed increased: total oil did not change. Assuming adult requirements of 56 grams protein per day, the increase in total protein from one hectare, after six cycles of selection, will provide sufficient protein for seven adults for one year. Compared to standard cultivars the increase provides the annual protein requirement for four adults.

Nitrogen fixation not limited by photosynthate availability - Raleigh, NC.

Male sterile plants with greatly reduced pod and seed development should transport more carbohydrates from the leaves to the root system as an energy source for increased nitrogen fixation. Much of the increased carbohydrate supply in the roots, however, was metabolized to starch and not used as an energy source. This indicates that factors other than photosynthate availability limit nitrogen fixation rates in nodulated soybean root systems.

Early determinate variety for high yield environments - Wooster, OH, in cooperation with Illinois and Ohio Agricultural Experiment Stations. The first early (Group III) determinate variety, 'Elf,' was released for high yield environments where lodging is a deterrent to higher yields. Elf is about one half the height of 'Williams,' has excellent resistance to lodging, and has yielded as much as 20 percent more in narrow, 17 cm rows in high yield environments.

Peanuts:

Two new peanut varieties released - Tifton, GA, in cooperation with Georgia and Florida State Experiment Stations. 'Tifrun,' a commercial runner and 'Early Bunch,' a Virginia market type, were released in 1977. Tifrun has a strong shell that minimizes insect and mechanical damage, and has larger seed and higher yields than 'Florunner.' Early Bunch matures up to 10 days earlier and yields 5 percent more than Florunner and averages about 75 percent Virginia-size pods.

Resistance to aflatoxin in peanuts discovered - Tifton, GA. Screening more than 3100 accessions of peanuts for resistance to aflatoxin produced by the fungus Aspergillus flavus has identified three lower yielding, Valencia-type peanut genotypes as most resistant to the fungus. This resistance is being bred into our most productive varieties: advanced lines have survived a very drastic laboratory screening for resistance to aflatoxin from two to six generations. Aflatoxin-free peanuts can return \$200 or more per ton to the farmer.

Collection of peanuts and their wild relatives - Stillwater, OK, in cooperation with the International Board for Plant Genetics Resources, FAO, Rome, Italy. An international team of peanut geneticists collected new and rediscovered species and races of peanuts in Brazil, Argentina, Bolivia, and Paraguay. The 1977 collection includes 118 cultivated peanuts, 43 wild species of Arachis, and 91 Rhizobium nodule collections from peanuts.

Sunflowers:

Excised embryo culture technique developed - Davis, CA. A technique of excising and culturing embryos from interspecific crosses was developed, which will allow interspecific crosses to be grown to maturity. Interspecific hybridization among species of sunflowers is required to provide the transfer of pest resistance and fatty acid composition genes to domesticated sunflowers.

Resistance to bird damage discovered - Fargo, ND. Breeding materials were screened for resistance to bird depredation and some lines exhibited resistance to bird damage. The nature of this resistance appears to be correlated with phenolic content of the mature seed. This may provide an index for selection of lines resistant to bird damage.

Sunflower germplasm pool established - Bushland, TX. Sunflowers are native to the U.S., and during the past 2 years an effort has been made to collect all 49 species. Currently, the collection of 900 accessions contains 46 of the 49 recognized species of sunflowers. This germplasm is of interest to the U.S. and World for sources of pest resistances and other specific traits.

Host plant resistances to insects discovered - Bushland, TX. Wild sunflower species were evaluated for resistance to insects. Host plant resistances to sunflower beetle, aphid, and carrot beetle were found.

Flax

Two new plant fatty acid metabolites identified - Fargo, ND. A new product of linolenic acid metabolism in flax has been identified as 12-oxo-cis-10, 15-phytodienoic acid. This compound contains a cyclic ring structure similar to that found in prostaglandins. The ability to produce cyclic products from readily available plant materials will be of interest to the pharmaceutical industry. In addition, it indicates that fatty acid products may have a growth regulating role in plants. 12-oxo-cis-9-dodecenoic acid was found to be an intermediate in the formation of 12-oxo-trans-10-dodecenoic acid (a physiological wound hormone). Amounts of this endogenous hormone in wounded tissue of flax and watermelon seedlings increased with time.

Genetics of open-flowered character and restoration of cytoplasmic male sterility determined - Fargo, ND. The open-flowered characteristic in flax was determined to be controlled by a single, dominant gene. Identification of a complete and stable male-sterile line was hindered by modifying fertility factors or minor restoration genes which lack expressivity under certain environments. Restoration of fertility to cytoplasmic male-sterile female lines was effective.

Safflower:

New method to rapidly evaluate safflower seedlings for cold tolerance developed - Tucson, AZ. A turntable was installed within a cold chamber to program a cold stress (-16°C for 4 hours after controlled hardening). In a four-way cross in which one parent was a cold tolerant selection from the wild species, Carthamus flavesens, none of the most cold tolerant domestic parent, about 50 percent of the wild parent, and 0.5 percent of the seedlings in the segregating population survived. Thus it appears feasible to breed safflower for additional cold tolerance, making it possible to grow safflower as a winter annual.

Multiple disease resistance in safflower released to breeders - Beltsville, MD. A safflower breeding line, LMVFP, was developed with resistance to lettuce mosaic virus, verticillium wilt, fusarium wilt, and phytophthora root and hypocotyl rots. The line has vigorous growth habit, striped-hull seed with high oil content, high yield, and has performed well in California and Arizona.

Technical Objective 2.

New and improved cultural and management practices that increase oilseed crop yields, minimize production losses, improve quality attributes, and conserve and use scarce resources efficiently.

Research Locations:

5206	Davis, California
7602	Gainesville, Florida
3311	Urbana, Illinois
3302	West Lafayette, Indiana

3408	Ames, Iowa
1109	Beltsville, Maryland
7402	Stoneville, Mississippi
3402	Columbia, Missouri
7802	Raleigh, North Carolina
3307	Wooster, Ohio
3608	Brookings, South Dakota
7302	College Station, Texas
7314	Vernon, Texas
7812	Suffolk, Virginia

Selected Examples of Recent Progress:

Soybeans:

Inhibitory effect of combined N on nodulation elucidated - Urbana, IL.

The well documented inhibitory effect of soil nitrogen on nodulation was shown to be an indirect effect. Nodulation and nitrogen fixation were enhanced when NO_3^- metabolism was depressed by inhibiting nitrate reductase activity. This enhancement of nodulation occurred in the presence of high external concentrations of NO_3^- , ruling out a direct effect of the NO_3^- ion. It was concluded that NO_3^- inhibits nodulation by incorporating the available carbon in the plant tops and thus depriving nodules of carbon needed for N_2 fixation.

Soybean seed quality improved with systemic fungicides - West Lafayette, IN.

Incidence of seed infection by *Diaporthe* was reduced by foliar applications of systemic fungicides. Combinations of benomyl and a contact fungicide gave better control than benomyl alone.

Soybean powdery mildew disease controlled by fungicide - Ames, IA.

Powdery mildew of soybeans was effectively controlled by benomyl applied as a spray at a rate of 1 g of 50 percent wettable powder per liter of water until runoff. Yield losses of susceptible varieties not protected by the fungicide were approximately 20 percent at two northern Iowa locations.

Highly efficient N_2 -fixing *Rhizobium* do not increase seed yields -

Beltsville, MD. Nine strains of *Rhizobium japonicum* were characterized as highly efficient in N_2 -fixation. Inoculation trials with four highly efficient strains at two locations did not give significant yield increases as compared to the uninoculated control treatment, because of competition from indigenous rhizobia. Addition of chlorosis-inducing strain 94 during elevated soil temperature resulted in increased recovery of strain 94.

Subsoiling or chisel plowing increases root density but not seed yields -

Stoneville, MS. 'Tracey' and 'Bragg' soybeans grown on soil subsoiled 45 cm deep had higher root densities at 15-30 and 30-45 cm depth increments, at 68 and 89 days after planting. Both subsoiling and deep chisel plowing (30 cm deep) increased root density of Tracey over the 125 cm profile. Yields were not significantly different among tillage treatments.

Soybean production systems compared - Columbia, MO. Soybean production systems were compared for the past 3 years: (1) Early June plantings yielded more than early May plantings; (2) Soybeans planted "no-till" yielded less than soybeans planted into a conventional seedbed; and (3) Soybeans that were cultivated or sprayed with an additional postemergence herbicide yielded more than soybeans with only a preemergence herbicide application.

Subsoiling or chisel plowing increases soybean yields - Raleigh, NC. Subsoiling or chisel plowing increased soybean yields 1 out of 4 years on a Norfolk soil and each of 2 years on a Wagram soil. The yield increases, 300 to 800 kg/ha, were obtained when moisture stress limited growth during late flowering and early pod set, and were due to greater utilization of subsoil moisture.

Maximum yields with early, determinate soybeans in narrow rows - Wooster, OH. 'Elf' (determinate) and 'Williams' (indeterminate) soybeans yielded essentially the same in 75-cm rows, but yields of Elf were 2.3 and 4.8 q/ha more than Williams in 38- and 17-cm rows, respectively. These results were obtained from larger plots utilizing chemical weed control and commercial combine harvesting, thus confirming the commercial feasibility of solid seedings of soybeans.

Peanuts:

Irrigation water use efficiency determined - College Station, TX. 'Tamnut 74' and 'Florunner' peanuts in automated rainshelters were irrigated on a soil moisture basis as determined by tensiometers. Yield, grade, and crop value increased linearly from 3.2 to 15.8 inches of total water for Tamnut 74 and 3.3 to 18.2 inches of water for Florunner. Water use efficiency was highest at 9.5 and 10.7 inches of water for Tamnut 74 and Florunner, respectively.

Remote sensing estimates peanut disease - Suffolk, VA. Remote sensing by aerial infrared photography has been used since 1974 to study two serious diseases of peanuts, *Cylindrocladium* black rot and *Sclerotinia* blight. Each disease has its specific spectral signature which has been confirmed by field pathology. The aerial photography provides accurate information on disease severity and rate of spread, thus providing data for disease loss estimates. It is estimated that *Sclerotinia* blight costs Virginia peanut growers more than 3 million dollars in 1976.

Sclerotinia blight controlled by experimental fungicide - Suffolk, VA. An experimental fungicide provided excellent control of *Sclerotinia* blight of peanuts. At harvest, 75 percent of plants in untreated plots were infected but less than 1 percent of plants sprayed with the experimental fungicide were infected. Yields and returns for untreated and treated plots were 2816 lbs/acre and \$552/acre, and 5375 lbs/acre and \$1122/acre, respectively. *Sclerotia* count at harvest averaged 28 and 2 for untreated and treated plots, respectively.

Sunflower:

Sunflower moth larvae enhance Rhizopus head rot - Davis, CA. In field tests, the highest incidence (100%) of head rot occurred in heads inoculated with the Rhizopus fungus and larvae of the sunflower moth. Inoculations with Rhizobus alone resulted in few rotted heads; rot did not develop in heads inoculated only with laboratory reared larvae. In laboratory studies, the spores of Rhizobus were viable after passing through the gut of the larvae.

Flax:

Increase in dryland flax yields with growth regulators - Brookings, SD. Seed yields in a dryland test in 1977 were significantly increased by GA₃ + Zn applied at bloom stage, NC9634 at bloom stage, TIBA postbloom, and dichlorflurenol treatments. Chlorflurenol caused a marked delay in senescence but did not increase seed yield.

Safflower:

Phytophthora root rot best controlled by resistant varieties and by planting on beds - Davis, CA. VFstp-1 germplasm exhibits resistance to phytophthora root rot. Bed planting was superior to flat planting for control of phytophthora root rot of irrigated safflower.

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National Research Program 20090

BREEDING AND PRODUCTION - SUGAR CROPS

This National Research Program involves research in breeding and production of sugarcane, sugarbeets, and sweet sorghum. New varieties, hybrids, and breeding lines are developed to improve yield, pest resistance, and drought, cold, and salt tolerance. Cultural and management practices are developed that will improve sugar and sirup yields and reduce production costs. Geneticists, plant pathologists, physiologists, and agronomists work as teams within commodities, sometimes with State researchers, to accomplish the mission.

NPS Contact: N. I. James

PACS Contact: L. L. Jansen

Technological Objective 1.

Develop new and improved breeding lines and varieties that combine high yielding potential and favored quality characters with better pest resistance, drought-cold-salt tolerance, and adaptation to mechanized culture, harvesting, handling, and storage.

Research Locations:

5205 Salinas, California
5602 Fort Collins, Colorado
7613 Canal Point, Florida
5220 Aiea, Hawaii
7412 Houma, Louisiana
1110 Beltsville, Maryland
1108 Beltsville, Maryland
3508 East Lansing, Michigan
7403 Meridian, Mississippi
3602 Fargo, North Dakota
5702 Logan, Utah

Selected Examples of Recent Progress:

Sugarbeet:

Beet Western Yellow Virus reduces yield of adapted breeding lines from 4% to more than 30% - Salinas, CA. In six tests, good correlations ($r=0.61^{**}$ to 0.99^{**}) between yellows score and sugar yield loss were obtained. The tests showed that appreciable genetic variability exists for resistance. Sugar yield losses in hybrids were intermediate to their parental lines, and losses in hybrids could be predicted from reaction of parental lines.

Two *Erwinia* resistant parental lines released for use in California and Arizona hybrids - Salinas, CA. Pollinator parents of hybrids grown in California and Arizona are highly susceptible to bacterial soft rot incited by *Erwinia*. Losses to the disease are estimated at \$10 million annually. Use of the new lines should reduce or eliminate this loss.

Eleven parental lines and two random mating populations released for use by private breeders - Salinas, CA. Parental lines with bolting resistance and resistance to various diseases such as yellowing viruses, curly top, and *Erwinia* soft rot were released for use as hybrid components or sources of resistance. Two random mating populations with multiple disease resistance and genetic variability for sugar yield combining ability were released as sources of disease resistance.

Recoverable sucrose is 15% greater in triploids when tetraploid is seed parent and diploid is pollen parent as compared to the reciprocal - Fort Collins, CO. Significant differences between triploid hybrids and their reciprocal equivalents were found for both yield and quality components. In addition to a 15% increase in recoverable sucrose, the non-sucrose components NA, K, and total N were 9%, 16%, and 11% lower when the seed parent was tetraploid.

Predictive models developed for thin juice purity - Fort Collins, CO. Predictive models for thin juice purity were developed using multiple regression and path coefficient analysis on juice components. Raw juice and thin juice purities were correlated 0.45 to 0.6. The predicted and actual thin juice purities were correlated about 0.85. Predicted purities were superior to actual raw juice purities for assessment of thin juice purity in both pre- and post-harvest beets.

Twelve breeding lines released for use by private breeders - Fort Collins, CO. These breeding lines have resistance to one or more of the diseases, *Cercospora* leaf spot, curly top virus, and *Rhizoctonia* root rot. They are recommended for use as hybrid components or as sources of improved disease resistance.

Triploid hybrids derived from *Rhizoctonia* resistant tetraploid pollinator and susceptible diploid seed parent may provide adequate field resistance - Fort Collins, CO. Triploid hybrids with two sets of chromosomes carrying genes for resistance and one set with genes for susceptibility are superior to 1:1 hybrids. This phenomenon, coupled with partial dominance, demonstrates to sugarbeet breeders that hybrid varieties may need resistance in only one parent to provide adequate *Rhizoctonia* root rot resistance.

New source of male-sterile cytoplasm - Beltsville, MD. After 22 years of breeding work, a male-sterile line has been developed in *Beta maritima* cytoplasm that performs well when used as a hybrid component in Michigan and Ohio. This alternate source of cytoplasmic male sterility could be extremely valuable if the present source of cytoplasmic male sterility proved to be susceptible to a disease such as happened with the Texas cytoplasm in corn.

Five monogerm male-sterile breeding lines released that show improved disease resistance in the eastern United States - Beltsville, MD. Five new male-sterile lines and the maintainer lines for two of these were released in 1977. All of the lines have potential for replacing male-sterile lines now used as hybrid components in the eastern United States. They are more resistant to *Cercospora* leaf spot and black root disease than lines now in use.

Multigerm pollinator line released for use in eastern United States - East Lansing, MI. EL 42, a new multigerm pollinator line, has some resistance to *Rhizoctonia* root rot and good resistance to *Cercospora* leaf spot and black root disease. Experimental hybrids using EL 42 as the pollinator have shown improved root yield, sucrose percentage, and clear juice purity in Michigan and Ohio.

Two storage rot resistant breeding lines released for use by private breeders - Fargo, ND. Breeding line F 1002 is resistant to the three major storage rot fungi, *Phoma betae*, *Penicillium claviforme*, and *Botrytis cinerea*. F 1001 is resistant to *P. betae* and *P. claviforme*. These lines are expected to contribute to reduction of storage pile losses when used as sources of storage rot resistance or as components of hybrids.

Immature sugarbeet roots can be evaluated for storage rot resistance - Fargo, ND. Eighty-day-old roots can be evaluated for resistance to *Phoma betae* and *Botrytis cinerea*. This reduces the time required for testing by 63% as compared to testing mature roots and doubles the number of roots that can be evaluated in one year in a given amount of cold storage space.

Two cycles of selection reduce sugarbeet root maggot loss by 14% - Logan, UT. Two cycles of repeated selection for low root maggot damage resulted in breeding lines that are 14% more resistant than the parent variety. This demonstrates the feasibility of developing hybrids that will resist maggot damage, produce better stands, and, consequently, higher yields in most sugarbeet growing areas of the United States and Canada.

Selection technique for yield in seedling stage saves time - Logan, UT. A new selection technique for root yield was developed that will reduce the time required to develop improved hybrids by one-third to one-half. Superior plants or lines are identified in the seedling stage by measuring the root diameter under controlled conditions. Young plants with larger root diameter yield more at maturity.

Eight breeding lines released for use by private breeders - Logan, UT. These breeding lines have differing superior qualities ranging from curly top resistance to excellent combining ability for root yield and sucrose percentage. Three of these lines are monogerm, and five lines are multigerm.

Sugarcane:

New sugarcane variety, CP 70-1133, released for commercial production in Florida - Canal Point, FL. CP 70-1133 is an excellent stubbling, high-tonnage, self-stripping, late flowering variety with medium fiber content. In the average of 18 replicated yield trials, it surpassed the leading commercial variety in Florida (CP 63-588) in indicated yields of sugar per acre by 36% and 29% for early and late harvests, respectively. CP 70-1133 is equal in stalk weight to CP 63-588 and has a 0.98 mill-ability factor compared to a 1.00 for CP 63-588. CP 70-1133 has adequate resistance (for commercial production in Florida) to sugarcane mosaic

virus, leaf scald (incited by *Xanthomonas albilineans*), and eye spot (incited by *Bipolaris sacchari*). CP 70-1133 appears to have cold tolerance similar to CP 63-588.

Salt-resistant cell lines developed from callus and shake cultures - Aiea, HI. Cell lines that grow in media containing 1.8% NaCl have been selected. Attempts to regenerate plantlets from these cell lines have failed thus far.

Resistance to Fiji disease established through tissue cultures - Extramural - Aiea, HI. Lack of resistance to Fiji disease in the Hawaiian sugarcane cultivars is recognized as a serious threat to the industry. Resistance, slow and difficult to obtain by conventional breeding and selection, has been obtained in about 2 years by tissue culture techniques. The tissue culture derived clones may prevent the establishment of Fiji disease as a problem in Hawaii.

New sugarcane germplasm introduced in commercial gene pool - Houma, LA. The first major infusion of new germplasm into the commercial gene pool in mainland United States is represented by 27 BC₃ progeny of *Saccharum spontaneum*, clone US 56-15-8. These clones equalled or exceeded commercial variety CP 65-357 in yield of sugar per acre and were more resistant to sugarcane mosaic virus.

Sweet Sorghum:

Sweet sorghum cultivars, Mer. 68-2 and Mer. 69-13, excel in sugar production - Meridian, MS. These cultivars exceeded commercial cultivar Rio in sugar production at nine locations in Louisiana, Mississippi, and Texas. They are being jointly released in the three States.

Technological Objective 2.

Develop new and improved cultural and management practices to increase sugar and sirup yields, minimize production losses, improve quality attributes, and efficiently conserve scarce resources.

Research Locations:

5205	Salinas, California
5602	Fort Collins, Colorado
7613	Canal Point, Florida
5220	Aiea, Hawaii
7412	Houma, Louisiana
1110	Beltsville, Maryland
3508	East Lansing, Michigan
7403	Meridian, Mississippi
3602	Fargo, North Dakota
5702	Logan, Utah

Selected Examples of Recent Progress:

Sugarbeet:

Close relationship established between beet western yellows virus and barley yellow dwarf virus - Salinas, CA. Serological and host range studies in California and New York have established a close relationship between the two viruses. Beet western yellows virus is the most economically important virus of dicotyledonous plants, and barley yellow dwarf virus is of extreme economic importance in monocotyledonous plants. The relationship could have special significance in the spread of this important virus complex.

Two toxins produced by *Cercospora beticola* and two chemicals produced by *Cercospora* leaf spot infected sugarbeet plants isolated - Fort Collins, CO, and Salinas, CA. *Cercospora* leaf spot, an economically important fungal disease of sugarbeet, was studied by an interdisciplinary team of scientists. Fine details of the disease were studied by electron microscopy which showed that the fungus did not penetrate into host cells until very late in the disease, after damage to the plant had already occurred. This suggested that fungal toxic materials might be important in the early stages of the disease. From cultures of the pathogenic organism, two toxic substances were isolated. These toxins and two chemicals made by the plant in response to the disease were purified and their amounts determined. This knowledge ultimately will contribute to plant breeding programs to increase resistance to the disease.

Epidemiological studies of powdery mildew, a new disease in the United States, aid in providing economical control measures - Fort Collins, CO. When powdery mildew first reached epidemic proportions in western sugarbeet areas in 1974, a survey indicated that the disease spread from south to north and west to east along three main routes by prevailing winds. Epidemiological studies showed that the fungus does not overwinter in plant debris, that the fungus only attacks plants in the genus *Beta*, and that susceptibility of sugarbeet increases with age of plant. Thus, chemotherapy was shown to be unnecessary and uneconomical before the plants are about 2 months old.

Sexual stage of *Phoma betae* produced and observed in the United States-Fargo, ND. *Pleospora bjorlingii* is the sexual stage of the important sugarbeet pathogen, *Phoma betae*. It was produced and observed for the first time in the U.S. by inoculating *P. betae* onto sugarbeet seedstalks then weathering the stalks outdoors. The sexual stage is the primary source of genetic variation in this class of fungi and is the overwintering stage. This discovery will allow study of the *Pleospora* life cycle and determination of inheritance of pathogenicity. Genetic knowledge of the pathogen is extremely important for a thorough understanding of a host-pathogen relationship.

Penicillium funiculosum, a new storage rot pathogen discovered - Fargo, ND. *Penicillium funiculosum* was associated with moldy sugarbeets in commercial storage in 1977. The fungus proved to be pathogenic. *P. cyclopium*, a reported but obscure storage pathogen, also was discovered. These fungi were very prevalent in this particular storage season and must be considered potentially dangerous. Advanced breeding lines and released

germplasms of storage rot resistant genotypes will be tested against these pathogens. These findings will direct further development of resistant germplasm.

Test developed to detect infection of commercial seed lots by the fungus, *Phoma betae* - East Lansing, MI. A sand emergence test was developed that detects *Phoma* infection of seed lots. The infection source was traced to Oregon seed fields where infection appears to spread from lesions on cut seed stalks to seed balls during rainy weather. The fungus causes stand loss at time of emergence and persists in some plants causing post-harvest storage losses. Control measures are being investigated.

Serological techniques developed for detection of curly top virus - Logan, UT. Two serological techniques have been developed for rapid assay of curly top virus (CTV). The latex flocculation technique can identify CTV in tissue extracts in less than one hour whereas previously two weeks were required. The fluorescent antibody technique can be used to locate CTV in infected hosts by direct observation for the first time in over 70 years of studying this virus. These tools will greatly facilitate study of the virus in its host and vector.

Harvest injury and crown removal are the most important factors that contribute to storage losses - Logan, UT. A 2-year study on the effect of harvest injury on respiration rates and sucrose loss during 150 days of storage was concluded. The results indicated that injury caused by crown removal and injury caused by mechanical harvesting are the two most important factors contributing to increased sucrose loss in storage.

Sugarcane:

Water control with drip irrigation reduces loss due to flowering and improves water use efficiency - Aiea, HI. Field flowering can be reduced by shock treatments such as imposition of drought or chemical applications timed to coincide with the period of floral induction. Floral induction is not constant for all cultivars in all locations, so attempts are made to determine factors controlling induction and to develop long-lasting prevention measures. Water control with drip irrigation was found to be a very effective method for reducing flowering. Moreover, the water saved in the flower control treatment was available for use on newly planted crops.

Winter stunting partially eliminated with low levels of gibberellic acid - Aiea, HI. The decreased solar radiation and lower temperatures of the Hawaiian subtropical winter season result in reduced growth in sugarcane. Cultivars selected for growth in cool mountain regions showed a positive growth response to low levels of gibberellic acid (GA₃) and no additional response to higher levels. Cultivars selected for growth in warm lowland regions showed increasing response to increasing levels of GA₃. A good correlation ($r = 0.723$) was found between the mean daily radiation of the environmental range of the cultivar and the cultivar's response to increasing levels of GA₃. Apparently, an environmentally induced gibberellin deficiency limits the zones over which sugarcane cultivars are best adapted. The slower winter growth rate reduces yield below that of summer by about 15 tons cane per acre during each winter encountered by

the crop. GA3 was found to restore about half of the growth lost to winter stunting and is equivalent to about 0.7 ton sugar per acre.

Close row spacing increases tonnage without sacrificing sugar content-Houma, LA. Sugarcane planted 2 feet apart on flat rows gave tonnage increases of 62% when compared to traditional 6-foot banked rows. These plantings minimize the disadvantage of a short growing season by efficient use of available land and light. Row spacing has no effect on sugar content. Sustained yields at this level could maintain a competitive position for Louisiana sugar production and could lead to sugarcane biomass production for alcohol.

New immunoflorescent diagnostic method for detecting ratoon stunting disease - Beltsville, MD. The indirect fluorescent antibody (IFA) technique is a sensitive, specific method for detection of the bacterium associated with ratoon stunting disease (RSD). This technique can detect the bacterium in samples 10-100 times less concentrated than was required by the phase contrast microscopy method and may be used as a reliable method for determining the presence of the bacterium in cane juice samples. The IFA method is the most sensitive, rapid method available for accurate diagnosis of RSD.

New strain of sugarcane mosaic virus (SCMV) from Pakistan - Beltsville, MD. Isolates of mosaic from Pakistan resembled SCMV-F in symptoms produced on the differential cane varieties, but the isolates readily infect johnsongrass and SCMV-F does not. The Pakistan isolates have not been transmitted by *Dactynotus ambrosiae*, *Myzus persicae*, or *Rhopalosiphum maidis*, three common aphid species that transmit U.S. strains of SCMV. It is especially important that this isolate be kept out of the United States sugarcane growing areas because of the prevalence of johnsongrass.

Sweet Sorghum:

Mutagenic influence of sugarcane mosaic virus established - Beltsville, MD. Sugarcane mosaic virus may act as a mutagenic agent in sweet sorghum thereby affecting genetics of the crop and the continuing high performance of improved varieties. Heterogeneity was measured in segregating populations from a cross between two healthy sorghum parents and in progenies from a comparable cross in which the female was virus-infected. Heterogeneity was significantly greater in the progenies from the infected parent cross.

Close row spacing increases yield - Meridian, MS. Gross and net stalk yield was 15 to 25 percent higher from rows 24, 30, and 36 inches apart than from the conventional 42-inch row spacing. Brix, sucrose, and purity were not affected by row spacing.

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National Research Program 20100

BREEDING AND PRODUCTION - FORAGE CROPS FOR HAY, PASTURES AND OTHER
USES, INCLUDING TURF

This National Research Program outlines a research program on crop production efficiency to develop new knowledge and to increase crop and livestock productivity. Forage crops for hay, pasture, silage, and other uses, including turf; and grass and legume seed production represent a resource of major economic significance in the United States.

NPS Contact: R. F. Barnes

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Technological Objective 1.

New and improved genetic populations, breeding lines, and cultivars of forage crops with improved yield, special use characteristics, quality, pest resistance, and tolerance to environmental stress.

Research Locations:

3611	Palmer, Alaska
7702	Tifton, Georgia
3420	Manhattan, Kansas
7809	Lexington, Kentucky
1108	Beltsville, Maryland (PPGI)
1109	Beltsville, Maryland (PPHI)
3502	St. Paul, Minnesota
7502	Mississippi State, Mississippi
3416	Lincoln, Nebraska
5208	Reno, Nevada
1307	Ithaca, New York
7802	Raleigh, North Carolina
3605	Mandan, North Dakota
1302	University Park, Pennsylvania
1402	Wyndmoor, Pennsylvania
7708	Clemson, South Carolina
7302	College Station, Texas
7307	Temple, Texas
7811	Blacksburg, Virginia
5806	Prosser, Washington
3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Germplasm Releases - 1977

<u>Name</u>	<u>Location</u>	<u>Cooperation</u>	<u>Date</u>	<u>Culti- vars (C) or Breeding Line (B)</u>
Alfalfa:				
KS 76	Manhattan, KS	Kansas AES	3/25/77	B
Baker	Lincoln, NE	Nebraska AES Kansas AES South Dakota AES	3/28/77	C
NC Cr1	Raleigh, NC Reno, NV	North Carolina AES Nevada AES	3/29/77	B
NCW 21	Raleigh, NC Reno, NV	North Carolina AES Nevada AES	3/29/77	B
CUF-101	Tucson, AZ Davis, CA	California AES	6/7/77	C
MP-9	Reno, NV	Nevada AES	6/16/77	B
Liberty	Raleigh, NC Stillwater, OK	North Carolina AES Oklahoma AES	6/24/77	C
U-5560	Logan, UT	Utah AES	8/11/77	B
KS 77	Manhattan, KS	Kansas AES	9/27/77	B
Riley	Manhattan, KS Lincoln, NE	Kansas AES Nebraska AES	9/30/77	C
Grasses:				
Nueces Buffelgrass	College Station, TX	Texas AES SCS	6/23/77	C
Llano Buffelgrass	College Station, TX	Texas AES SCS	12/14/77	C

Aluminum-tolerant alfalfa developed - Beltsville, MD. Four cycles of selection for Al tolerance in Arc alfalfa have been completed. Cycles 1 and 2 were screened in Tatum soil; cycles 3 and 4 were screened in nutrient culture at pH 4.5. Nutrient culture evaluation of 5-week-old progeny from the four cycles revealed a 30-40% increase in plant height and top weight over Arc. Increased tolerance to Al could extend the use of alfalfa into new areas where subsoil pH is low and Al toxicity is high.

Alfalfa weevil resistance - Manhattan, KS. Glandular hairs are involved in resistance of Medicago species to the alfalfa weevil. Techniques have been developed for fixing plant tissue to study trichomes with the scanning electron microscope. Sections of leaflets and petioles from two diploid and three tetraploid Medicago species were fixed for observation. Interspecific crosses between annual glandular-haired Medicago species and M. sativa were made but pods abscised before seed matured. Excised immature seeds failed to grow on several artificial media. Fifteen-day-old M. sativa embryos and subsequent plants grew well on Linsmaier-Bednar (LM) and modified Whites media. Only callus tissue developed on Murashege-Skoog (MS) and Norstog's media.

Resistance to alfalfa blotch leafminer - University Park, PA. Heritability for the proportion of leaflets mined by Agromyza frontella in alfalfa was very low (4.18%). Predicted response to selection indicated that a combination of family and within family selection, similar to the modified ear-to-row procedure used in corn, was the most effective breeding method. Family size and the number of replications would have to be large, however. The perennial growth habit of forages permits the procedure to be more efficient in forages than in most applications with corn.

Alfalfa cultivars tolerant to crown rot - Raleigh, NC. Alfalfa bred in North Carolina showed less damage from Sclerotinia crown and stem rot than cultivars developed elsewhere. In field tests in consecutive years at Raleigh, NC, the tolerant cultivars had as little as 2% stand loss from Sclerotinia, while non-adapted cultivars showed up to 30% loss. Cultivars showing tolerance in one year also were tolerant the following year. Since we do not have effective greenhouse screening techniques for this disease, these results emphasize the importance of field selection and also the importance of growing cultivars adapted to the region.

Trifolium seed collection in Greece and Italy - Madison, WI. Seed of 292 accessions of Trifolium (clover) species and 75 accessions of other cool-season forage species were collected throughout Greece and Italy during June and July 1977. This material will be compared to existing cultivars of clovers to determine their potential for yield, disease resistance, and persistence. This material has the potential of having desirable genes controlling increased yield, better disease, and greater persistence. Forage breeders are continually demanding new germplasm to incorporate into their existing germplasm to generate new sources of variability.

Nitrogen-fixing legumes for forests - Tifton, GA. Two exotic legumes, Lupinus hispanicus spp. bicolor and Desmodium canum, that have growth habits and persistence to make them good nitrogen-fixing crops are being increased for evaluation as a forest cover crop. The better antiquality factors of these legumes that make them unsuited for forage will protect them as nitrogen-fixing plants in the forest.

Virus resistance in legumes - Clemson, SC; Raleigh, NC; Blacksburg, VA. Identifying virus resistance in white clover and other legumes is not absolute because all susceptible plants are not infected by one inoculation. The problem of frequent escapes is minimized by successively using four mechanical inoculations, two aphid inoculations, and field exposure. Results indicate that progress is being made in identifying virus resistance.

Important experimental tall fescue varieties developed - Lexington, KY. Two genetically distinct ryegrass-tall fescue hybrid varieties, designated G1-307 and G1-306 exhibit toxicity differences affecting feed intake of ruminants. Although G1-307 is significantly superior to G1-306 and Ky. 31 tall fescue for digestibility of dry matter, protein, ADF, and NDF--intake of ruminants is consistently reduced during summer and in experimental laboratories at high temperatures. Discovering and correcting poor performance of animals grazing tall fescue during summer could result in increased production of 65 to 160 million kg of beef annually. G1-307 and 306 offer a unique opportunity to solve a problem of great economic importance.

A hard fescue (*Festuca ovina* var. *duriuscula*) synthetic cultivar shows tolerance to sod webworm - Lexington, KY. Surviving plants selected from a severely sod webworm-injured sod were crossed to produce seed of a synthetic cultivar. The cultivar maintained excellent color, sod quality, and stand throughout the year while nine other ovinae-type fescue cultivars appeared dead by the end of the growing season. A sod webworm-tolerant cultivar of fine-leaf fescue would provide a valuable source of seed for lawn mixtures for utilization in shade.

Genetic variability and inheritance of in vitro dry matter digestibility and cell wall constituents of orchardgrass - Columbia, MO. For orchardgrass over 2 years and 3 harvests within each year, heritability estimates (narrow sense) for IVDMD ranged from 0.7 to 0.73 depending on mating design; correlations between parents and progeny were 0.84 to 0.89. Heritabilities for ADF ranged from 0.4 to 0.7 and for NDF, the heritability range was 0.1 to 0.5.

Improved techniques to decrease time required for breeding new forage grasses - Mandan, ND. Federal research scientists have evaluated several techniques to determine the feasibility of early identification of high-yielding forage grasses. Studies using reed canarygrass have shown that selection for high-yielding varieties is enhanced by selecting for high-photosynthetic and enzyme activity. The probability of selection toward a more drought-tolerant variety is also increased by evaluating the rate of water loss from leaves and the stomata frequency on the leaves. These techniques may decrease the time required to develop new forage varieties by 3 to 5 years.

Hybrid forage sorghum improvement - Lincoln, NE. In two cross-classified hybrid forage sorghum experiments involving 3 females x 8 males in 1973-75, and 13 females x 2 males in 1974-75, genetic ratios indicated that general combining ability often was relatively high for bloom, height, dry matter and yield, and was of some importance for

IVDMD and % Brix. Specific combining ability was most important for protein. Correlations among traits indicated that high silage yield often was positively correlated with tall height and late maturity; was negatively correlated with dry matter, protein, and IVDMD; and was not associated with % Brix.

Inheritance and linkage in pearl millet - Tifton, GA. In pearl millet, Pennisetum americanum, the inheritance of two new mutants was determined, and two linkage groups and the independence of two additional pairs of genes was established. This information will help us understand the genetics and breeding behavior which will aid in developing new varieties and hybrids.

Pearl millet rust overwinters on eggplant - Tifton, GA. Field experiments completed in 1977 proved that pearl millet rust Puccinia substriata var. indica can overwinter as teliospores and infect eggplant as a means of reoccurring each year in the Tifton area. This information will permit planning cropping systems to prevent carryover of rust from one year to another.

Inbred Tift 186 and Gahi 3 F₁ hybrid pearl millets registered - Tifton, GA. Pearl millet inbred Tift 186 is immune to Pyricularia leaf spot, is the male parent for the Gahi 3 F₁ millet hybrid and maintains the sterility of the Tift 23DA female parent in the F₁ hybrid. These characteristics enhance the quality of Gahi 3 and help to explain why Gahi 3 in a 2-year grazing test gave 21% better average daily gains (ADGs) and liveweight gains (LWGs)/A than Gahi 1. Substituting Gahi 3 and Gahi 1 will increase livestock production 20% with the same inputs increasing profits for the livestock farmers and eventually lowering beef prices.

Tifton 44 bermudagrass looks good - Tifton, GA. Tifton 44 bermudagrass has yielded as much dry matter as Coastal in repeated tests, and in 1976 and 1977 gave 19% better daily gains when grazed or fed as pellets. It survived the winter of 1976-77 very well at Stillwater, Oklahoma, and Simpson, Illinois, and reports from 30 plant and animal scientists in 14 States indicate that it is well adapted throughout the South. It will be released in 1978 and should increase the efficiency of the livestock industry in the South.

Improved quality found in bermudagrass - Tifton, GA. Two new bermudagrass hybrids T68 and T84 had higher in vitro dry matter digestibility than currently used cultivars. These two hybrids also showed smaller decreases in digestibility with age indicating that new varieties which maintain better quality can be developed. The T84 bermudagrass is more leafy, which should further enhance forage quality.

New buffelgrass cultivars released - College Station, TX. Nueces and Llano buffelgrass are apomictic true-breeding F₁ hybrids with improved forage yield and cold tolerance. Well established stands of these cultivars have survived up to 100 miles farther north than the presently available cultivars, T-4464 (Common) and Higgins. They also provide superior, more reliable cultivars for areas farther south

where T-4464 and Higgins are subject to winter kill when temperatures drop below 20°F.

Centipedegrass mode of reproduction established - Tifton, GA. Centipedegrass, Eremochloa ophiuroides, was found to be a sexually reproducing species with regular chromosome behavior and a self-incompatability system operating. The information will be useful in seed production and improvement of the species.

Improvement of common dallisgrass - Temple, TX. In an effort to improve common dallisgrass, an investigation of its progenitors is underway. By producing hybrids between different Paspalum species and cytologically determining the amount of chromosome pairing in the hybrids, the relationship of the species crossed can be determined. It was determined that yellow-anthered dallisgrass and a related species, P. jurgensii, were not related to P. malacophyllum. The relationship between dallisgrass and P. conspersum was made clearer when the relationship between P. conspersum and P. jurgensii and P. intermedium was determined.

Buffelgrass improvement - College Station, TX. Buffelgrass is one of several apomictic grass species vitally important to grassland agriculture in the Southwest. Improvement of these grasses depends upon discovery of sexual types to permit hybridization, effective control and manipulation of mode of reproduction and introduction of germplasm from the native habitat. Lack of germplasm and sexual plants have restricted breeding progress and increased the risk of genetic vulnerability. Present breeding programs are based on crosses onto plants derived from one sexual clone and thus only one source of cytoplasm. A collection trip to the native habitat in South Africa in 1976 yielded over 700 different biotypes representing a vast array of potentially valuable germplasm. Evaluation of 436 buffelgrass accessions revealed a wide range of different biotypes and considerable promising germplasm. Types having the desirable combination of extensive rhizome development, high seed production and superior forage production were seen for the first time. Past efforts to develop strains with all of these traits have been unsuccessful due to lack of appropriate germplasm. Preliminary cytological studies and progeny evaluation have shown no evidence of sexual reproduction in these accessions.

National Foundation Seed Project - Prosser, WA. Grower cooperators produced 66,860 pounds of foundation seed of seven improved forage crop varieties. The foundation seed will be used to produce certified seed from which an estimated 10 million acres can be planted for forage.

Technological Objective 2.

New and improved cultural and management practices that increase forage crop yields, minimize production and utilization losses, improve feed quality, conserve and use scarce resources efficiently, and enhance environmental quality.

Research Locations:

3611	Palmer, Alaska
7602	Gainesville, Florida
7702	Tifton, Georgia
7903	Watkinsville, Georgia
3302	Lafayette, Indiana
1109	Beltsville, Maryland (PPHI)
3502	St. Paul, Minnesota
7502	Mississippi State, Mississippi
3402	Columbia, Missouri
1307	Ithaca, New York
7802	Raleigh, North Carolina
7318	El Reno, Oklahoma
1302	University Park, Pennsylvania

Selected Examples of Recent Progress:

Determined energy-use efficiency of forage production systems - St. Paul, MN. To identify forage production methods with increased energetic efficiency, stand establishment practices were subjected to an energy analysis. The total energy inputs to alfalfa establishment with an herbicide (clear-seeding) are 6% greater than the energy inputs to establishing alfalfa with an oat companion crop in southeastern Minnesota. The total crop energy yield from clear seeded alfalfa is more than double that of alfalfa seeded with a companion crop. This is largely the result of more dry matter being harvested from 2 cuttings of clear seeded alfalfa than from the oat companion crop in the alternate system. Comparisons of energy yield/energy input of the two systems reveal that the energy balance of clear seeded alfalfa, 7.3, is more than double that of alfalfa established with a companion crop, 3.6. Greater capture of sunlight in harvestable plant products, rather than a major difference in the various fossil energy inputs, is the basis for the difference in energy efficiency of the two systems.

Assay of hydrocyanic acid potential in sorghum - Lincoln, NE. The p-hydroxybenzaldehyde-based assay was used to compare the hydrocyanic acid potential (HCN-p) of first leaves of sorghum seedlings and young leaves of tillers. Highly significant r values were obtained, indicating that seedling HCN-p was useful in predicting HCN-p of older plants. However, spectral scans indicated that much more interfering material was present in the tillers than in young seedlings. Thus, this assay is best suited for use with young seedlings.

Effect of air temperature and photoperiod interactions on yield of high- and low-yielding clones - Beltsville, MD. Twelve alfalfa clones differing in yield and tolerance to harvest were grown at four temperature regimes (29-24 C, 26-21 C, 23-18 C, and 20-15 C day-night temperatures) at two photoperiods (10 and 14 hr). Photosynthetic rates and dry weights were obtained. The optimum day-night temperature regime (within the restraints of our experimental design) for the genotypes used in this test is warmer (26-21 C regime) under a 10-hr photoperiod than at 14 hr (23-18 C regime). The 10-hr photoperiod results in a faster rate of total nonstructural carbohydrate (predominantly

starch) accumulation in the leaves during the photoperiod than a 14-hr photoperiod. This suggests partitioning of assimilates is programmed by the light and/or dark period.

Effect of soil moisture stress on nutrient uptake and dry matter accumulation in alfalfa - Lafayette, IN. A reduction of soil moisture, particularly in the top 31 cm, resulted in reduced alfalfa hay yields and higher levels of total non-structural carbohydrates in the roots and stems. In these periods of moisture stress there were significantly higher levels of calcium in leaves, nitrogen and magnesium in stems, and nitrogen in roots; also lower levels of potassium in leaves; potassium, iron, and aluminum in stems; and calcium in roots. The effect of soil temperature has not been fully evaluated.

Rate of N₂ fixation in alfalfa determined - Beltsville, MD. Four harvests of a field study to assess the levels of N₂ fixation in seven alfalfa cultivars using ¹⁵N-treated soil were taken. Analyses revealed that in five healthy, productive cultivars 70-75% of the N₂ in the plant tops resulted from atmospheric N₂ fixation. In two diseased cultivars N₂ fixation was reduced to 35-45%. Apparently disease-resistant alfalfa cultivars will be required to obtain high levels of N₂ fixation.

Significant progress in improving the nitrogen fixation capacity of alfalfa - St. Paul, MN. Field studies of nodulation and nitrogen fixation, as measured by ¹⁵N, provided preliminary information that greenhouse selection has been effective in increasing the nitrogen fixation ability of alfalfa. The developmental sequence of the alfalfa nodule was clearly defined at both the light and electron microscope level. Biochemical studies indicated that leghemoglobin, indoles, and phenolic compounds may interact to regulate nodule growth. Field and laboratory studies indicated that soil nitrogen levels similar to those found in the corn belt may limit nodulation during seedling establishment. In summary, the information obtained in 1977 was extremely encouraging. Larger scale field studies using newly selected experimental lines are planned for 1978. The objectives of these studies will be to integrate the new plant breeding, plant physiology, and plant biochemistry findings under several environments.

Growth hormones produced by Azospirillum spp influence plant growth - Gainesville, FL. Extensive efforts in the United States and elsewhere have been directed toward the elucidation of the mechanism by which Azospirillum (formerly Spirillum) spp influence the growth of tropical C-4 plants. An inherent assumption common to all reported studies is that dinitrogen fixation by rhizosphere Azospirillum sp cells must be involved when positive growth responses occur. We have shown that (a) increased dinitrogen fixation usually cannot be detected by the acetylene reduction technique, even in carefully controlled experiments in which plant growth rates increase after inoculation and (b) phytohormones produced by Azospirillum are capable of increasing plant growth rates. The evidence from these experiments is that assumptions about the effects of Azospirillum spp on tropical C-4 plants are partially or totally in error.

Plant growth hormones detected in several diazotrophic bacteria - Gainesville, FL. Bacterial species known to fix nitrogen in the root zone of nonleguminous crop plants were found to produce large quantities of indoleacetic acid and cytokinins. The isolated cytokinins were found to increase growth of the plants in some instances. A smaller quantity of a material with gibberellin activity also was isolated. The production of these highly active plant growth substances by the bacteria suggests a highly important mechanism by which nonpathogenic rhizosphere bacteria may affect the ontogeny of host plants.

Legume-grass mixtures - Columbia, MO. Growing a legume with the warm-season grass caucasian bluestem, should increase the yield and quality of herbage, provide a more even distribution of forage production, and eliminate the need to apply N fertilizer. Under frequent cuttings (5 times/season) to simulate pasture conditions, yield of dry matter for caucasian bluestem grown alone was 5.2 mt/ha as compared to 11.2 mt/ha for caucasian bluestem grown with 'Dawn' or 'Cascade' birdsfoot trefoil or 'Kenstar' red clover. Stands of caucasian bluestem grown with legumes ranged from 60 to 88% of the botanical composition in September. On a hay-cutting schedule (3 cuttings/season), red clover appears to be depleting stands of the bluestem. Results from growing legumes with 'Pathfinder' switchgrass parallel those with caucasian bluestem.

Studies have uncovered anatomical and morphological traits of forage grasses which can significantly increase rate and extent of digestion - Beltsville, MD. Evidence continues to accumulate which points to major opportunities to modify plant surfaces to improve rumen microbial penetration. Increased penetration rate results in decreased time for microbes to get in place to digest cellulosic materials within the plant. The earlier the attachment of the microbe, the earlier the digestion. Scanning electron microscope examination showed colonies of microbes attached to the waxy leaf surface. The G14 mutant of Gateway barley is clearly different in its susceptibility to penetration by microbes.

Antiquality constituents in tall fescue - Beltsville, MD. Continued studies to elucidate tall fescue's antiquality constituents in cooperation with animal scientists. The grazing studies in 1977 of four lines of tall fescue repeated the observation on animal performance in 1976. Animals grazing K-307, the high perloline line, expressed the summer syndrome (summer slump) characteristic. Mineral analysis of plant samples showed no clear association with antiquality constituents. All fescue samples appeared low in selenium. Phenols, aflatoxins or steroids could not be associated with the differential response.

Laboratory methods of assay forage quality - St. Paul, MN. Acid detergent fiber was found to be the best of numerous chemical assays for predicting digestibility of corn and sorghum silages and a modified cell wall procedure and crude fiber were the best chemical predictors of intake potential of sorghum silages. Equations were developed for prediction of digestible dry matter and intake of silages from biological and chemical assays.

Rapid technique being developed for determining forage quality - University Park, PA. A long-time dream of plant breeders, agronomists, animal nutritionists, and livestock producers is beginning to be realized. Samples of hay and other forages and feedstuffs can now be rated for quality very rapidly without even destroying the samples in the process. The final test of a forage's value is how it affects an animal's performance. But feeding trials require a ton or more of each forage, weeks or months to complete, and are very expensive. Cooperative research at University Park, Pennsylvania, between USDA-SEA-FR and The Pennsylvania State University promises to reduce greatly the time and money currently expended for animal feeding trials and expensive chemical analyses to determine forage quality. Using near infrared reflectance spectroscopy (IR), a forage sample can now be given several quality scores in 2 minutes. Information from the IR instrument is fed into a computer and the amounts of crude protein, fiber, and other constituents are estimated and printed automatically. This technology, when development is completed, promises to greatly aid breeders of forage plants, who must screen thousands of different individual plants annually. Extension specialists will find the procedure especially useful in advising farmers and feed-mill operators concerning ration formulation, and the marketing of hay will become more orderly and efficient. Livestock producers will be able to produce milk and meat more efficiently, as feed supplements and forages can be used more rationally to furnish balanced animal diets at lower costs.

Meadow vole bioassay - University Park, PA. A meadow vole bioassay was used to evaluate the relative significance and interactions of some antiquality plant constituents on intake of semisynthetic diets in single-meal treatments. Three alkaloids, gramine, tryptamine, and hordenine, found in reed canarygrass, and 3-nitropropionic acid (NPA), found in crownvetch, were fed in various concentrations and combinations. Inhibition of intake by hordenine was less on a weight percentage basis but equal on a molecular basis to gramine, tryptamine, and NPA. The inhibitory effect of the alkaloids on intake was additive and a synergistic effect was obtained with diets that contained mixtures of gramine and NPA. It was concluded that hordenine should get greater attention than it presently receives in plant breeding work with reed canarygrass, and further studies of the interactions of these compounds on intake by ruminants appear warranted.

Characterization of forage root systems - University Park, PA. Studies of the characterization of root systems of forage species grown on slant-boards (Crop Sci. 14:317, 1974) was continued. The design of the slant-board covers was modified to direct the nutrient solution through the absorbent material before reaching the roots. This reduces dislodging of fungi and insects during watering and has enhanced our studies with the clover root curculio. A methodology study was made to develop a technique for identifying genotypes of legumes most efficient in root production when grown with limited mineral supplies in gravel culture. Plants from 10 legume seed lots were grown in each of five dilutions of Hoagland's nutrient solution in gravel cultures. The greatest differences in plant size between and within seed lots occurred at the lowest mineral-supply treatments. The technique appeared to be useful

for screening plant genotypes and for identifying plant characteristics associated with production under conditions of limited mineral supply.

Sequences of grass-legume mixtures for quality forage production - Mississippi State, MS. Annual and perennial Trifolium species grown in sequences have provided 12-month production of grass-legume forage. Proper use and management of clovers in these systems should result in a savings of labor and machinery costs involved in the production, handling, storage and preservation of feed for livestock. Winter annual clovers grown with winter annual grass and/or cereals on a prepared seedbed produced forage from October until May with an average of 6,800 kg/ha dry matter. Red, T. pratense L., and white, T. repens L., clovers over-seeded on a 'Coastal' bermudagrass, Cynodon dactylon (L.) Pers., sod produced high-quality forage from April until October and averaged 11,100 and 7,800 kg/ha dry matter, respectively, with no fertilizer nitrogen.

Species mixtures maximize forage legume production - Mississippi State, MS. Annual clovers mixed with red clover provide greatest distribution of yield and higher total forage production. Spring yields of mixtures were 63, 30, and 43% higher than each annual clover grown alone for 'Amclo' arrowleaf, 'Mt. Barker' subterranean, and 'Tibbee' crimson clovers, respectively. Tibbee crimson makes more fall and winter growth than other winter legumes. A mixture of Tibbee crimson clover with red clover provides maximum forage for grazing throughout the growing season.

Forage utilization - Raleigh, NC. Evaluation of crownvetch (CV) for continuous grazing showed cows and calves to each gain 0.96 kg/hd/day. CV yielded 3,375 and 325 kg/ha of TDN and calf gain, respectively, when stocked at 2.63 cow-calf units/ha. During the second year of grazing, stands thinned to 83%. Continuous grazing during the following year reduced stands to 10% CV compared with 38% where CV was clipped during the third summer. CV was successful from animal response data but not successful agronomically (slow establishment and regrowth and poor persistence when continuously defoliated).

Warm-season grasses for summer pasture - Columbia, MO. Efficiency of red-meat production can be increased with pasture systems utilizing warm-season grasses for summer grazing. On many Southern Corn Belt farms, cattle may lose up to a pound weight/day during the hot summer months from mid-June to August when grazing temperate grasses such as tall fescue or orchardgrass. In contrast, research at Mt. Vernon, Missouri, shows that cattle can be expected to gain weight throughout the grazing season on pasture systems where cool-season forages are grazed during the spring and autumn, and the warm-season grasses, caucasian bluestem, or switchgrass are grazed during the summer. Mid-summer gains of cattle have ranged from 0.8 to 1.5 lb daily on these perennial warm-season grasses.

Animal response to source of nitrogen for plant growth - Columbia, MO. Rate of gain of Hereford x Angus cross yearling steers was 36% higher on tall fescue interseeded in early spring with 'Kenstar' red clover ~~as~~ compared to tall fescue fertilizer with 141 kg N/ha. Fescue-red

clover steers averaged 0.53 kg gain/day vs. 0.39 kg/day for the N-fertilized fescue, but N-fertilized fescue gave 104 more animal days of grazing. Average daily gain and carrying capacity were significantly different ($P=.05$), but gain/ha was not. Steers on both fescue-red clover and N-fertilized fescue ended the season with 14.4% fat and 18.8% protein as determined in a low-level radiation whole-body counter. Changes in body composition (% fat and protein) over the season were not significantly influenced by kind of pasture.

Improved grazing system for ruminant animals - St. Paul, MN. A cooperative pasture experiment between SEA-FR and the Minnesota Agricultural Experiment Station has revealed the efficiency of using the legume birdsfoot trefoil (BFT) to substitute for part of conventional alfalfa-grass systems. The lower yield of BFT was more than offset by its superior forage quality (digestibility, protein content, and intake potential) compared to alfalfa-grass. Therefore, the lambs' grazing systems having 2/3 alfalfa-grass and 1/3 BFT gained 23% faster and reached market condition more quickly than those grazing complete alfalfa-grass systems. The scientists reported 18% more animal gain per hectare over a 3-year period for the BFT-containing systems. They documented that this rather small change in pasture management practice (inclusion of higher amounts of high-intake potential legumes, such as BFT) can cause a sizable animal performance increase and greater efficiency for the producer of ruminant animals.

A systemic fungi removed from tall fescue - Lexington, KY. Epichloe typhina, a recently discovered endophyte in tall fescue, may influence tall fescue toxicosis in animals. Surveys showed that E. typhina was more prevalent in Gl-307 than in Gl-306. The experimental varieties, Gl-307 and Gl-306, are low and high in perloine, respectively. Fescue toxicosis is more prevalent on Gl-307. Benamyl, a systemic fungicide, was effective in removing E. typhina from infected parental clones of Gl-307. An effort is underway to produce Gl-307 forage with and without the fungus which will be fed to animals in high temperature laboratories to determine its toxic effect.

Viruses in alfalfa - St. Paul, MN. Alfalfa mosaic virus (AMV) is present in most alfalfa stands. Very little information is available on either direct losses caused by AMV in alfalfa or the interactions it may have with other alfalfa pathogens. In three successive seasons alfalfa seedlings of two Phytophthora root rot-resistant cultivars were inoculated with three strains of AMV and later subjected to conditions favorable to Phytophthora root rot. Root rot severity in AMV-infected plants was similar to non-AMV-infected plants, indicating no interaction between the two pathogens.

Verticillium wilt of alfalfa in the Northwest - Prosser, WA. Verticillium albo atrum pathogenic in alfalfa was found in Ontario; Oregon; and Meridian and Caldwell, Idaho; in 1977. These areas are in addition to Umatilla, Oregon; Willamette Valley of Oregon; Columbia Basin, Yakima Valley, and Pierce and Whatcom Counties of Washington. This indicates Verticillium wilt of alfalfa is widespread in the Pacific Northwest and

could be a major factor affecting alfalfa production in the area. Potatoes, tomatoes, and eggplant inoculated with the alfalfa strain of V. albo atrum in growth chambers were not visibly damaged by the organism. V. albo atrum was recovered from tomatoes and eggplant, but it has not been determined whether the recovered organism was the alfalfa strain or a different strain.

Incidence of bacterial wilt - St. Paul, MN. Corynebacterium insidiosum, the incitant of bacterial wilt (BW) in alfalfa survived in field soil for 7 years in the absence of alfalfa. Alfalfa plants infected with BW were plowed under and the field seeded to timothy. In addition to timothy, white clover, quackgrass, and other grass weeds became established. BW-susceptible cultivars were seeded into a different portion of the field in each of 7 successive years. BW symptoms were observed in some alfalfa plants the year following seeding in each planting. Four years after seeding, the stands were depleted. Apparently, the bacterium can survive in debris in soil for long periods, thereby eliminating the possibility of controlling BW by cultural methods.

New experimental fungicide effective - Tifton, GA. Ciba-Geigy CGA-48988 experimental fungicide was highly effective in protecting ryegrass from seed-rot and pre- and post-emergence damping-off. This fungicide will permit earlier fall planting of ryegrass for pasture and turf and extend the usefulness of this winter growing species.

Technological Objective 3.

New and improved cultural and management practices that increase forage crop and turfgrass seed yield, reduce production losses, and improve seed quality.

Research Locations:

3611	Palmer, Alaska
3302	Lafayette, Indiana
7317	Stillwater, Oklahoma
5809	Corvallis, Oregon
5806	Prosser, Washington
5802	Pullman, Washington

Selected Examples of Recent Progress:

Alternatives to open burning of postharvest residue of grass seed fields - Pullman, WA. An average loss of 32% in seed production occurred for mechanical removal compared with open burning in the second seed crop, 46% in the third seed crop, and 60% in older stands. Machine burning at high temperature (450° to 500° C) was the only alternative to open burning that maintained seed production. Machines for field burning are experimental at this time and are not economical. This research was a deciding factor in continuation of field burning in Washington and Idaho and has resulted in maintaining a viable grass seed industry in the area.

Influence of environment and management on genetic stability of forage crop varieties - Prosser, WA. Significant differences were not found in the progeny of the six parental clones of Vantage reed canarygrass grown in polycross nurseries at Ames, Iowa, and Prosser, Washington, in 1973 and 1974. Present results indicate that breeder seed of reed canarygrass can be produced under Washington climatic conditions without affecting genetic qualities. Since the evaluation test at Prosser was adversely affected by drought during floral development, data will be obtained again in 1978.

Plant physiological responses established for bermudagrass seed production - Stillwater, OK. Cultural and management practices involving fertilization, timing of spring mow-back, and irrigation practices to manipulate plant physiological responses to environment have been established for bermudagrass seed production in Oklahoma. Management practices or agronomic techniques that are timely in regulating plant responses to environment, provided that seed production is being attempted with clones that have a high degree of self-fertility and are cross-compatible or both is the key to successful seed production. Until now seed production (yield) or bermudagrass was thought uneconomical in Oklahoma. Seed yields from our best management plots have averaged 650, 843, and 828 kg/seed/ha for 1975, 1976, and 1977, respectively. Establishment of winter-hardy bermudagrass strains from seed has considerable cost advantages over sprigging, has the advantage of being used easily in confined areas, such as homesites, steep embankments, dams, and roadbanks. In addition, seed availability of adapted strains offers the potential of aerial seeding of rocky hillsides, the production of reasonably high forage yields, and quicker establishment on problem soil sites.

Seed production in Alaska - Palmer, AK. Numbers of seed heads produced by native Alaskan brome grass were not influenced by early May fertilizer topdressing in the year of seed production, even though N rates ranged from 0 to 188 kg/ha, and P_2O_5 rates from 0 to 233 kg/ha. Topdressing the same rates in mid-August of the year prior to seed production, however, markedly influenced numbers of panicles produced (3X to 9X increases over check). This reveals that provision of critical mineral nutrients in timely harmony with this northern grasses' pattern of initiating floral primordia during the year prior to heading can foster significantly increased seed production and monetary returns to Alaskan growers of seed of this species and other grasses similar in growth pattern, supplying expanding grass seed markets in the far North for forage and/or conservation uses.

Chemical control of grass seed diseases - Corvallis, OR. Sodium azide was tested in field plots for effectiveness in controlling ergot and blind seed diseases. The chemical suppressed ergot ascocarps when applied May 9 at 5 lb a.i. or April 27 at 20 lb but gave no control applied either October 18 or December 19. Sodium azide gave 95 percent control of blind seed apothecia when applied May 9 at 20 lb but no control when applied October 18. Other chemicals were far less effective. When available, the chemical would represent one substitute for field burning.

Chemicals for control of rust diseases of grasses - Corvallis, OR.
Triadimefon gave excellent control of stem rust in ryegrasses and stripe rust in bluegrass by two applications of 12 oz a.i./acre on numerous field plots. The study brought one step closer the control of grass rusts by a chemical that substitutes for nickel fungicides. The chemical promises to reduce costs of grass seed production by better rust control.

Technological Objective 4.

Turfgrass cultivars and genetic populations with increased pest resistance, tolerance to environmental stress, and improved agronomic characteristics.

Research Locations:

3611	Palmer, Alaska
1108	Beltsville, Maryland (PGGI)

Selected Examples of Recent Progress:

Evaluation of improved zoysia - Beltsville, MD. Evaluate zoysia for potential use on golf courses or home lawns. Two experimental selections of zoysiagrass are being increased for possible release. They spread faster, have better rust (Puccinia zoysiae) resistance, and have provided higher quality turf than Meyer and other selections in test for 6 years. Eighty-seven zoysiagrass hybrids and selections are being evaluated for rate of spread, leaf texture, color, winterhardiness, and disease resistance.

Technological Objective 5.

Improved cultural and management practices for turfgrasses that reduce the costs of maintenance, increase ground cover value, provide greater persistence, and improve aesthetics.

Research Locations:

1108	Beltsville, Maryland
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Selected Examples of Recent Progress:

Utilization of sewage sludge in turfgrass production - Beltsville, MD. Scientists have demonstrated the past 4 years that the use of composted sewage sludge as a soil amendment or growth medium in commercial sod production is an environmental and economically sound method of sludge disposal, as well as turfgrass production practice. This comes at a time when quantities of municipal waste are increasing and conventional disposal methods (ocean dumping, land filling, and incineration) are being restricted because of their specific limitations, and when the use of fertilizers on non-food crops is being questioned for conservation reasons. Studies are being continued to obtain further information on turfgrass quality.

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National Research Program 20110

IMPROVED VEGETATION AND MANAGEMENT PRACTICES FOR RANGE

This National Research Program involves research to develop new and improved technology to increase productivity from improved vegetation and management practices for range; to conserve, protect, and improve our Nation's range resources; and to enhance the multiple use of those resources. A multidisciplinary team approach of both Federal and State researchers are dedicated to this effort.

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Technological Objective 1.

Acquire, describe, and evaluate new germplasm; and develop and test improved cultivars of grasses, legumes, shrubs, and forbs with increased ease of establishment, productivity, forage quality, persistence, improved seed qualities, and tolerance to grazing, and with reduced losses from antiquity constituents, pests, and environmental hazards.

Research Locations:

5502	Tucson, Arizona
5602	Fort Collins, Colorado
5707	Dubois, Idaho
5708	Bozeman, Montana
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
5702	Logan, Utah

Selected Examples of Recent Progress:

Germplasm collection - Logan, UT. About 1,100 seed collections were obtained by D. R. Dewey and A. P. Plummer (Forest Service) during a 45-day plant-collecting expedition to arid and semiarid regions of the U.S.S.R. (the North Caucasus region and the Kazakstan Republic). The bulk of the collections were forage grasses, legumes, miscellaneous forbs, and shrubs. Significant collections were made of Agropyron, Astragalus, Bromus, Dactylis, Elymus, Festuca, Lotus, Medicago, Melilotus, Phleum, Poa trifolium, and Vicia species. The collections have been threshed and cleaned. Half of each collection will be kept at Logan, Utah, and the other half is being increased at Regional Plant Introduction Stations.

Germplasm evaluation - Logan, UT. Fifty-seven collections of Hordeum violaceum, a potentially useful meadow grass from Iran, were grown at Logan, Utah, where they were evaluated for morphological, cytological, and fertility characteristics. The collections included diploid

($2n=14$), tetraploid ($2n=28$), and hexaploid ($2n=42$) races, with hexaploid race being the most widespread. The tetraploids and hexaploids behaved cytologically as autopolyploids. This species-complex is one of the few naturally occurring autopolyploid series and should have special value in the study of the effects of autopolyploidy. Hordeum violaceum is, for the most part, self-sterile. Almost all other Hordeum species are self-fertile. The tetraploid race appears to have the greatest potential as a forage grass.

Breeding improved range grasses - Logan, UT. A breeding program to develop improved varieties of grasses for arid range, arid turf, and revegetation of surface mining areas concentrates on (1) crested wheatgrass (Agropyron cristatum, A. desertorum et al.), (2) Russian wildrye (Elymus junceus), and (3) promising interspecific hybrids, primarily A. repens X A. spicatum. A wide range of native and introduced Triticeae species are being screened for potential use in revegetating surface mining spoils.

Collection of important grasses in western North Dakota and western South Dakota - Mandan, ND. SEA scientists are cooperating with Soil Conservation Service personnel in the collection of 10,000 clones each of wheatgrass and blue grama. These two grasses are important species in the native vegetation of Great Plains ranges. The collection is the largest vegetative and most systematic collection of grass ever attempted in a domestic collection. The plant material will be used as base populations for plant breeding programs in the two species.

Seedling drought tolerance in Lehmann lovegrass - Tucson, AZ. Seedling drought-tolerant germplasm was developed and cultivars released. The surface wax structure was associated with seedling drought tolerance. This characteristic will serve as a valuable selection tool to isolate germplasm for seedling drought tolerance among Eragrostic sp.

Selection procedure developed for drought stress resistance - Logan, UT. Seedling emergence under drought stress was evaluated in 150 lines of crested wheatgrass using a soil-solute system. This procedure avoids direct seed and osmoticum contact, uses soil as a germination medium, and allows maintenance of a wide range of drought conditions. The same breeding lines have been examined for their ability to recover after a drought exposure period. Trays containing over 4,000 seedlings were given a drought exposure in a growth chamber that simulated early summer conditions. After the drought exposure, the seedlings were watered and given recovery ratings. The combination of these techniques will allow systematic selection for improving seedling drought resistance and will lead to enhanced seedling establishment in important range forages.

Survival of alfalfa under range conditions - Logan, UT. Selected cultivars and strains of alfalfa were seeded at five locations in northern Utah during 1953 and 1954. Average annual precipitation ranged from 20 to 36 cm. Observations and detailed plant counts showed a decline in alfalfa stand densities at four of the five sites. The reduction in plant density at two sites was attributed primarily to

livestock grazing and to severe damage by rabbits. Moisture stress was an additional factor at two other sites. Plant density has remained high at the fifth location for 23 years.

Valuable cicer milkvetch germplasm pools developed - Fort Collins, CO. Seed from two germplasm pools was produced in sufficient quantities to be released to other researchers. One pool was selected for excellent mature plant vigor and high seed weight. Mean forage yield and mean seed weight of the selected population were 117% and 112% of the cultivar 'Lutana,' respectively. The second pool was developed by selecting plants with average or above forage yield and high seed weight. Mean forage yield and mean seed weight of the selected population were 109% and 117% of the cultivar Lutana, respectively. These pools are valuable sources for selecting improved cultivars of cicer milkvetch because heavier seeds give increased seedling emergence from deeper depths of planting.

Legume species for range - Mandan, ND. An evaluation was initiated of 12 legume species for winter hardiness and drought survival when space-planted into range sod. A recurrent selection program for range adaptability in Medicago sativa and Lotus corniculatus is underway.

Technological Objective 2.

Develop range improvement practices for increasing productivity of rangeland.

Research Locations:

5502	Tucson, Arizona
5602	Fort Collins, Colorado
5707	Dubois, Idaho
5708	Bozeman, Montana
5709	Miles City, Montana
5208	Reno, Nevada
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
7307	Temple, Texas
5609	Cheyenne, Wyoming

Selected Examples of Recent Progress:

Nondestructive measurement of green biomass - Las Cruces, NM. Measurement of green biomass of grasses by nondestructive photometric methods has been successfully used for some range grasses. However, it appears to have limited potential for semi-desert species, primarily because of morphological characteristics which result in large amounts of standing dead material that tends to mask green biomass.

Technique to measure root surface area developed - Bozeman, MT. A technique was developed and tested to measure root surface area. Roots were placed inside a wire mesh basket in a stoppered plastic centrifuge

tube and brought to constant weight with H₂O. The tubes were centrifuged at a slow speed for a given amount of time before the basket and roots inside were removed and weighed on an analytical balance. The basket was replaced in the tube and centrifuged at a slightly greater speed. The basket and roots were again removed and weighed, with the difference in weights corresponding to the H₂O spun off the outer root layer which was used as a relative measurement of root surface area.

Effect of leaf morphology on light penetration into alfalfa canopies - Bozeman, MT. Leaf morphology had little effect on light attenuation in canopies, but large leaved canopies allowed greater light penetration than small leaved. Critical leaf area index (LAI) ranged from 4.5 to 7. The results indicate that little progress can be made in alfalfa yield through genetically engineering canopy structure.

Plant responses to enhanced solar UV-B radiation - Las Cruces, NM. Studies involving important native and agricultural plant species exposed to enhanced solar UV-B radiation exhibited reduced growth, as expressed in total leaf area, and wet and dry weights, photosynthesis and relative growth rates. Photosynthetic depressions were shown to be accumulative with time and dose while plant growth depressions were a function of dose. Under conditions of reduced atmospheric ozone, the resulting increase in solar UV-B radiation could have a significant impact on plant growth and agricultural productivity. However, it is not yet possible to predict with any certainty the expected reductions in plant productivity (native or agricultural plants) that would occur under specific increases in solar UV-B radiation.

Leaf surface variability of blue panicgrass populations - Tucson, AZ. Selected populations of irrigated blue panicgrass forage grown under seven stress environments were studied for variability in wax crystal morphology. The same framework of crystals was present on the leaf surface; however, differences in wax crystals existed among the plant populations. Further studies may result in a selection tool to isolate germplasm for stress environments.

Seedling establishment by punch planting - Temple, TX. Greenhouse tests of punch planting showed that seedlings emerged satisfactorily from punch plant holes that were four times the normal seeding depth. Under severe drying conditions, 1/4-inch diameter holes were superior to either 1/2- or 1-inch holes. Punch planting when the soil was very wet caused soil strength to limit plant growth. Under severe drying conditions with no added water, punch planting established better stands of seedlings than conventional seeding.

Seed dormancy and germination of native range species - Reno, NV, and Tucson, AZ. Germination and dormancy characteristics have been obtained for the desirable browse species of curlleaf cercocarpus, desert bitterbrush, and cliffrose. Seed of Lotus crassifolius and Sambucus glauca remained dormant and failed to respond to enhancement treatments (Reno, NV). The germination characteristics of Indian ricegrass seed have been studied.

Requirements defined for germination and establishment of blue grama - Fort Collins, CO. Blue grama, the dominant warm-season forage grass on the Central Plains, shows promise for the revegetation of sites where the native sod has been destroyed. Attempts to establish blue grama from seed often have failed. Field and controlled environment experiments revealed that development of crown roots requires temperatures between 15° and 30° C, 2 to 4 days with a continuously moist soil surface, and favorable moisture to a soil depth of 40 cm. These rather restrictive environmental requirements generally have to be met within the 2- to 6-week interval after seedling emergence. Root growth is severely reduced at higher and lower temperatures. Brief thunder showers do not supply adequate moisture for root development. The results suggested criteria for genetically improving blue grama and practices for reducing planting failures.

Establishing forage grasses on Natrustoll (Solonetz) soils in saltgrass meadows - Fort Collins, CO. Converting low-value unpalatable saltgrass areas to pastures containing productive, palatable forage species is extremely difficult because of unfavorable soil conditions which include an impermeable sodic B horizon and a saline-sodic C horizon. Russian wildrye is a promising species for this site because it appears to be surviving the drought better than crested wheatgrass, tall wheatgrass, or smooth brome, and it appears to be fully as tolerant as tall wheatgrass. The major problem with Russian wildrye is that it has low seedling vigor and is difficult to establish. Tall wheatgrass has the most salt-tolerant seedlings.

Curing of standing flood meadow forage - Burns, OR. Flood meadow forage can be successfully cured with a low level of Paraquat and can provide suitable grazing for wintering beef animals. Cost of this method is estimated at 1/3 the cost of conventional haying and winter feeding. This technique would result in great savings in time and energy in range livestock production, if paraquat can be registered for this use.

Renovation of overgrazed mixed prairie rangeland with N fertilization - Mandan, ND. Native range overgrazed for 50 years was returned to a high level of both forage production and livestock carrying capacity after 2 consecutive years of N fertilization at 40 pounds per acre of actual N per year without interruption of grazing use. Species composition was improved through stimulation and increase in density of the cool-season mid-grasses, with an accompanying decrease in density of blue grama. During the last 10 years of the study, a 30 percent increase in carrying capacity and an additional 100 pounds of gain per animal resulted from the fertilized range compared to the untreated portion. This management practice is being adopted under actual ranching operations. Several million acres of range, historically overgrazed in the Northern Great Plains of the United States and the Prairie Provinces of Canada, would respond to this treatment.

Magnesium deficiency (grass tetany) a threat at low temperatures - Cheyenne, WY. When air or soil temperatures fall below 10° to 15° C, the magnesium content of wheatgrasses and brome-grasses may fall below

0.2%. Cattle grazing these grasses may develop symptoms of grass tetany, a magnesium deficiency. However, orchardgrass, tall fescue, and alfalfa maintained magnesium levels above 0.2% even at low temperatures. Fertilization with 1,120 kg magnesium per hectare had no effect on magnesium content of forages, but magnesium content of all the species studied increased as temperatures reached 26° C.

Water ponding for increasing available moisture - Las Cruces, NM.

Water ponding is being used as a means for increasing soil water for forage production. Where water has been ponded to a depth of 7.6 cm, the soil profile has been wetted to 2.4 m versus essentially no available soil water in the control area. Soil water was available for plant growth below the 0.3 m depth throughout the year.

Comparative drought effects upon grasses and legumes - Fort Collins, CO.

Crowns of blue grama seedlings of three ages were exposed to drought treatments of -30, -60, -90, -120, or -180 bars for 2 days with the use of constant humidity environments. Crowns were then planted in moist soil (about -0.3 bars) for a 10-day growth test at 25° C. Percentage survival of crowns decreased with a decrease in water potential during the temporary drought treatment and with decreasing seedling age at time of treatment. Percentage survival of 21-, 28-, and 35-day-old crowns treated at -180 bars was 5, 54, and 83, respectively. These survival percentages were significantly different ($p < 0.01$). Measurements of adventitious root growth during the 10-day test indicated that short-term, moderate plant drought (water potentials of not less than -60 bars) did not severely limit adventitious root development in young seedlings.

Germinating seeds (seminal primary root 3 to 5 mm long) of cicer milkvetch, alfalfa, Russian wildrye, and crested wheatgrass were dried for 4 days in eight constant humidity treatments, ranging from -100 to -2,200 bars, to simulate temporary drought in field plantings. The legumes were more susceptible to drought injury than the grasses ($p < 0.01$). For example, average percentage survival of legumes and grasses after treatment at -600 bars was 17 and 88, respectively. The legumes depended for survival on the development of a replacement tap root; the grasses depended on the development of one or more seminal lateral roots.

Blue grama die-off - Fort Collins, CO. Large areas of blue grama have died on the Central Plains Experimental Range, apparently caused by a white grub. Abundant third instar grubs were found in the die-off areas in 1976 and the spring of 1977, but they apparently pupated and emerged. Sampling in late summer of 1977 found mainly small first instar grubs concentrated in the transition zone between live and dead blue grama areas and in the vicinity of cactus and saltbush plants. This concentration would indicate a probable increase in the size of the affected die-off areas as the grubs grow larger and consume roots.

Range grasses give variable response to burning - Burns, OR. Native bunchgrasses were more susceptible to spring than to mid-season or late-season burns. Stipa spp. were extremely susceptible to early and

mid-season burns. These results suggest that prescribed burning research should be concentrated on late-season burns to minimize damage to desirable grasses.

Improving ranges infested with creosotebush - Las Cruces, NM. There are virtually no residual grass stands on range sites dominated by creosotebush nor is there any substantial revegetation following control of the shrub. Creosotebush was successfully controlled by root plowing and the site seeded with Lehmann and Boer lovegrasses, black and sideoats gramas, blue panicgrass, yellow bluestem, and fourwing saltbush. Yields of these desirable species have averaged 765 lb/A (702 kg/ha).

Reclaiming mesquite sand dunes - Las Cruces, NM. Mesquite has increased rapidly on rangelands in the Southwest. On sandy soils, unprotected soil is deposited around the mesquite plants and eventually forms sand dunes. Aerial spraying of mesquite with 1/2 lb/A 2,4,5-T results in a measure of control and a reversal of the site deterioration. An area sprayed twice for mesquite control had an average yield of 182 lb/A of air-dry perennial grass herbage compared to 29 lb/A on an adjacent unsprayed area. With mesquite control, the sand dunes on the sprayed area have leveled appreciably and wind erosion has been markedly reduced.

Technological Objective 3.

Develop grazing (forage-livestock) management systems which convert range forage more efficiently to animal products and are consistent with improvement, conservation, and multiple use of range ecosystems.

Research Locations:

5602	Fort Collins, Colorado
5707	Dubois, Idaho
5709	Miles City, Montana
5208	Reno, Nevada
5507	Las Cruces, New Mexico
3605	Mandan, North Dakota
7316	Woodward, Oklahoma
5810	Burns, Oregon
5609	Cheyenne, Wyoming

Selected Examples of Recent Progress:

Microscopic method for estimating cattle diets - Cheyenne, WY.

Regression equations were calculated to predict weight of various forages in cattle diets from the number of fragments of each species observed by microscopic examination of diet samples. Correlation coefficients (r^2) between weight and fragment number were .61-.73 for western wheatgrass, .60-.64 for blue grama, .33-.79 for needleandthread, .99 for sedges, and .55 for forbs. Except for needleandthread, equations and correlation coefficients were similar between years and observers.

Nitrogen supplementation to grazing cattle on blue grama range - Fort Collins, CO. On shortgrass native range, slow-release nitrogen supplements have less nutrient value per unit of protein equivalent than natural protein supplements. Analysis of a 3-year grazing trial on blue grama range during winter showed that weight gains of yearling heifers increased as protein level increased on loamy plain sites, but not on overflow sites. Nonprotein nitrogen supplements--starea, buiret, and isobutyldiurea--produced the same gains as a low-protein cottonseed meal supplement that supplied only 60% as much protein equivalent and an equal amount of energy.

Range shows minimum response when protected from grazing - Burns, OR. Density and cover changes of sagebrush both inside and outside of grazing exclosures erected in 1936 and evaluated in 1974 reveal only small changes while that of rabbitbrush has increased. Additionally, no strong shifts in the grass understory have occurred. These results suggest that increased grass production through elimination of the grazing animal is neither rapid nor of great magnitude and that brush reduction through elimination of grazing does not occur in the sagebrush-bunchgrass zone. Rapid increase in the productivity of these brushlands will come by direct technological techniques that reduce brush cover and replace existing forage species or cause them to increase by themselves.

Calf production doubled by use of crested wheatgrass - Cheyenne, WY. When crested wheatgrass pasture, grazed spring and fall, replaced about 10% of the shortgrass native range used for cow-calf production, carrying capacity on the range + crested wheatgrass combination was 1.33 AUM/ha, as compared to .74 AUM/ha on range alone. Even with the higher carrying capacity, gains of cows, heifers, and calves were as high on range + crested wheatgrass as on range alone, and 25 kg calf weaned per hectare, compared to 13 kg on range alone. Production per hectare would have been higher on both systems if only cow-calf pairs had been grazed, but about 2 replacement heifers were carried for every 3 cow-calf pairs. Of the cows exposed to AI or bulls, 85% became pregnant on range + crested, vs. 81% on range alone.

Improved pastures triple carrying capacity - Burns, OR. During the course of this project, yearling livestock gains on irrigated pasture were increased from 0.5 kg average daily gain (ADG) to as much as 1.2 kg through manipulation of management and supplementation. Increased ADG was accomplished as follows: grazing rotation, 0.18 kg; copper supplement, 0.14 kg; barley supplement, 0.14 kg; fly control, 0.04 kg; pasture legume, 0.09 kg; and pasture grass, 0.2 kg. Improved pastures tripled the carrying capacity and beef gains expected from unimproved native meadow.

Evaluation of pasture and hay mixtures - Bozeman, MT. Evaluation of Regar bromegrass was completed at three locations. This grass has been superior to all recommended grasses in Montana. Over a 3-year period, it contributed 1.10, 1.87, and 2.00 tons per acre more to mixtures than Manchor smooth bromegrass at Bozeman, Kalispell, and Huntley, Montana. The grass is already being used by ranchers in large plantings, and its use will expand rapidly.

Improved range beef production from crossbreeding - Las Cruces, NM.

The dominant breed of cattle in the southwestern United States is Hereford. Crossbred cows, Hereford--Santa Gertrudis or Hereford--Brangus, had an average pregnancy of 85%; whereas, the average pregnancy of Hereford cows was 70%. The conception rate of Hereford cows was reduced more during drought years than any of the breeds of crossbred cows. The weaning weight of calves from the crossbred cows averaged 370 lb and from the Hereford cows it averaged 291 lb.

Dietary overlap between wild and domestic animals - Burns, OR. Feces examinations indicate the dietary overlap between antelope, deer, wild horses, cattle, and sheep on a typical desert wintering area is limited to grass in early spring and fall months. Juniper, sagebrush, and bitterbrush were major dietary constituents for deer and antelope during summer, fall, and winter. This information will assist range and wildlife managers in programming resource allocations within the sagebrush-bunchgrass zone.

Integrated forage production systems on range - Reno, NV. Yearling steers on various combinations of forage from crested wheatgrass, native range, and native meadow forages gained from 1.59 to 1.82 lb/day, for the period 5/19 to 9/8. Highest gains were from meadow forage; lowest gains were from range forage. Animals fed meadow aftermath (9/8 to 10/29) plus barley or alfalfa graded standard - to standard + when slaughtered on 10/29. Animals on aftermath plus 3.5 lb/day barley from 9/8 to 1/27 graded good - to good +. Yearlings carried over as 2-year-olds reached slaughter weight of 875-900 lb in 90 days when fed barley at 1% of body weight + alfalfa; in 193 days when fed alfalfa; in 207 days when fed grass and alfalfa; and in 284 days when carried through winter on grass hay, then grazed on range in spring and summer.

Cattle grazing effects on soils with vesicular surface horizons - Reno, NV. Cattle trampling of vesicular, crusted surface soil increased density of young, big sagebrush plants 36% and decreased density of grasses and forbs 8 to 29% when compared with untrampled soils. Most young plants (82%) were in cracks between surface polygons, 18% on the polygon surfaces. Trampling increased density of young plants emerging from polygon surfaces by 425%. Soil moisture, nitrogen, and livestock use affected the number of reproductive culms, seed production, and seed test weight of Thurber needlegrass. These characteristics of squirreltail were affected only by livestock use.

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National Research Program 20160

INTRODUCTION, CLASSIFICATION, MAINTENANCE, EVALUATION AND DOCUMENTATION OF
PLANT GERMPLASM

Research is directed to provide breeders and other applied plant scientists with the genetic resources needed for improving crop plants in terms of their reaction to environmental stresses such as insect and disease pests, adverse weather, and moisture supplies, and in terms of compositional characteristics and nutritional factors. It also provides for a continuing evaluation of new plant resources that have the potential of becoming viable new crops which can provide raw materials needed for changing industrial and medical technologies or to meet national requirements for strategic materials.

NPS Contact: Quentin Jones

PACS Contact: L. L. Jansen

Technological Objective 1.

Expanded collections and improved maintenance, evaluation, and distribution of plant germplasm as sources of useful genetic material to improve existing crops and developing new crops.

Research Locations:

3611	Palmer, Alaska
0709	Boulder, Colorado
5602	Fort Collins, Colorado
1211	Washington, D.C.
7616	Miami, Florida
7707	Experiment, Georgia
7705	Savannah, Georgia
3408	Ames, Iowa
1108	Beltsville, Maryland
1205	Glenn Dale, Maryland
1308	Geneva, New York
7617	Mayaguez, Puerto Rico
5802	Pullman, Washington
3509	Madison, Wisconsin

Selected Examples of Recent Progress:

Computer assisted information system for national plant germplasm program - Boulder, CO, and Beltsville, MD. A feasibility study to assess the need for and dimensions of an information system to service the national plant germplasm program was completed. The study team concluded that an information system should be implemented and must address the following constraints and objectives:

1) An effective data and information system is necessary for preserving and utilizing plant genetic resources.

- 2) The information system must serve the users of germplasm.
- 3) The development of the system must realistically reflect the availability of funds for all plant genetic resources activities.
- 4) The data and information system must account for requirements in each activity related to the preservation and use of plant genetic resources.
- 5) The concept of data compatibility must be well understood and accepted.
- 6) The national information system must be coordinated with the system being developed internationally.

Behavior of stored coated vegetable seeds - Fort Collins, CO. A 3-year study using coated and uncoated carrot, lettuce, and onion seeds showed that coated and uncoated seeds maintained viability equally well at 5°C and 40% relative humidity. Under less favorable storage conditions, coated seeds lost viability more rapidly than did uncoated seeds. Some temperature/relative humidity combinations induced dormancy in coated lettuce seeds. Seed coatings reduced germination of vegetable seeds in laboratory tests made by the standard germination test methods.

Deterioration of isogenic lines of pearl millet - Fort Collins, CO. Sixteen chlorophyll deficient (CD) isolines of pearl millet were artificially aged. Homozygous recessive CD genotypes and homozygous normal green genotypes showed the same pattern of deterioration during storage.

Investigate the effects of ultracold temperatures on seed viability - Fort Collins, CO. Tests on seeds of 110 species indicate that most seeds which can be dried to low moisture contents without loss of germination can be subjected to temperatures as low as -196°C without damage. Lettuce, bluegrass, tall fescue, and sorghum seeds with over 15% moisture content were damaged by freezing. Seeds with under 15% moisture were not damaged at temperatures as low as -196°C.

Avocado tolerance to low temperatures - Miami, FL. The freezing weather of January 19, 1977, destroyed all flowers (and consequently the 1977 crop) on most avocados in the Miami collections, thus affording an excellent natural means of screening for cold tolerant germplasm resources. Of F_1 and F_2 seedlings derived in part from Mexican stock, 753 trees less than 7 years from seed included 24 that flowered after the freeze. The most outstanding hardiness was shown by a small tree located in a field where no other avocados bore fruit. It was uninjured, whereas many others showed severe injury. The fruit quality of this selection is not adequate to justify its introduction as a named variety, but its potential as a parent in combination with high-quality cultivars such as 'Ettinger' is obvious.

Avocado genetics - Miami, FL. Isozyme analysis initiated early in 1977 indicated that each avocado cultivar possesses its characteristic enzymic pattern. Once determined, this may be used to differentiate genotypes and to determine the extent of selfing and crossing in seedling populations derived from 2 parents of differing genotype.

Effect of sodium vapor light on plants - Miami, FL. The freeze in January killed all of the young plants in the light test, setting these experiments

behind one year. All have been replanted. It was noted prior to the loss that Dombeyas under both 5 and 20 foot candles flowered 6 weeks later than the controls, and an unidentified stem boring larva that attacked Erythrina fusca in the controls was absent in the plants under lights.

Coffee germplasm collection - Miami, FL. Screening for cold tolerance in Coffea arabica continued this year following the low temperature of -4°C during January. Sixty-three percent of the plants in the field survived and can be considered as extremely cold tolerant. Seeds of about 70 of these were sent to research stations at the southern extremity of coffee growing regions in Brazil and Argentina.

One hundred thirty-eight peppers were screened for resistance to tobacco mosaic virus - Experiment, GA. P.I. 159261 showed no symptoms and the virus could not be recovered from inoculated plants by indexing on Nicotiana glutinosa. In addition, many introductions show a local lesion reaction which appears to be similar to the reaction of previously-reported sources of resistance.

Plant introductions contribute to alfalfa release - Ames, IA. Three alfalfa introductions, P.I.'s 107298 (Turkey), 206278 (Turkey), and 234205 (Iran) var. 'Bam' contributed germplasm to the variety 'Baker' released jointly by ARS and the Nebraska AES.

Useful characteristics in plant introductions - Ames, IA.

P.I. 195401 from Guatemala and P.I. 142899 from Iran were evaluated at Michigan and are considered to have the potential for improving the nutritional status and food quality of commercial beans.

Four corn introductions, P.I.'s 172323, 172324, 172327, and 195239 appear to have some 2nd brood European Corn Borer resistance. Five corn introductions, P.I.'s 186233, 210402, 221888, 222637, and 233001 showed good resistance to spider mites in evaluations in New Mexico.

Two cucumber introductions, P.I. 137847 from Iran and P.I. 390244 from Japan are being used in a breeding program at Michigan for their resistance to Triazine. They are being used for studies of mechanism of resistance and inheritance.

Fifty-three vegetable cultivars, representing 18 plant species, recently introduced from People's Republic of China, were evaluated for resistance to viruses affecting similar crops in the Northeast United States. Twenty-four of these cultivars were resistant or tolerant to one or more viruses. New sources of resistance are reported for four viruses in three plant species.

Citrullus lanatus, P.I. 189225 from Belgian Congo and P.I. 271778 from South Africa are practically immune to Collectotrichum lagenarium (anthracnose) isolates from cucumbers used in the USDA cucumber disease screening program in Wisconsin.

Six wheatgrass introductions outyielded and outperformed the check variety, 'Slate' in several ways at Nebraska. They are P.I.'s 345586, 273733, 273732, 315355, 315067, and 315353. It is highly recommended, by the evaluator that these accessions be evaluated by other wheatgrass breeders.

Selections from screening ornamental varieties - Ames, IA. Abeliophyllum distichum, Caragana frutex 'Globosa', Ilex verticillata, Lonicera tatarica 'Valencia', Lonicera xylosteum 'Emerald mound', Potentilla fruticosa, and Viburnum opulus 'Compactum' plants have performed exceptionally well under the severe climatic conditions of the Northern Great Plains Region.

Disease resistance to Rhizoctonia fruit rot in tomatoes located in a Plant Introduction - Ames, IA. This disease has become one of the major diseases of both fresh market and processing tomatoes in the eastern half of the United States. The change to mechanical harvesting in recent years has accentuated the importance of this disease because of the longer period of time needed between maturity and harvest to assure maximum once-over yields. The single-gene resistance located in P.I. 193407 should be easily incorporated into commercial varieties.

Potential sources of resistance to sunflower moth found - Ames, IA. Evaluation of the entire sunflower collection for resistance to sunflower moth showed that three introductions have potential as sources of resistance: P.I.'s 172906, 204578, and 380569. Among susceptible introductions, infestations were greatest in large-headed, shorter, early maturing sunflowers.

New plant introductions - Beltsville, MD. In 1977, new plant introductions consisted of 6,651 items including 1,800 vegetables, 1,760 forages, 921 oilseeds, 919 cereals, 446 ornamentals, and various other crops. Of perhaps special interest are 250 vegetables from the People's Republic of China, 337 ornamentals from Japan and Okinawa, and 368 forages -- mainly Trifolium -- from Italy, Greece, Crete, and Switzerland.

New accessions added to the Small Grains Collection totaled 2,633 (foreign - 2,432; domestic -201). Seed stocks were increased in the fall-sown nurseries: Mesa, Arizona, 6,819 rows; and at Aberdeen Idaho, 1,556 rows. The spring-sown nursery at Aberdeen, Idaho, consisted of 5,263 rows and 2,434 hills of Avena sterilis. There were 957 pots grown for seed increase in the Beltsville greenhouse. Plant scientists received 176,326 packets of seed from the collection. There were 80,698 samples sent in 267 foreign shipments; and 95,628 samples sent in 264 domestic shipments.

RNA and viruses - Glenn Dale, MD. The discovery of a very low molecular weight segment of ribonucleic acid which is unrelated to the host virus on which it depends for "survival" and which greatly modifies the disease that the host virus usually causes is a new phenomenon and one that we feel to be highly significant. Implications of this phenomenon are far reaching because this virus is able to infect most of the economically important crops of the United States. We already know that the specific cause of a multimillion dollar loss in the French tomato crop was due to

this unusual combination of disease agents. Both of these agents -- the virus and the "foreign" RNA of unknown origin in the plants -- have been found in several places in this country. Ultimately we would hope to identify those diseases, if any, that may be caused by these agents.

Plant introductions contribute to variety releases - Pullman, WA.

A cultivar of Festuca ovina "Covar", was selected from P.I. 109497 from Turkey and released by the Soil Conservation Service.

Two lettuce cultivars, 'Calrey' and 'Calrico', which provide downy mildew resistance obtained from plant introduction parentage, were released by the California Station.

Two breeding lines of peas resistant to seedborne mosaic virus (PSbMV) and pea enation mosaic virus (PEMV) were developed from P.I. accessions. The pea cultivar, 'Corvallis', was developed from a plant introduction selection and released by the Oregon Station.

A new paprika-type pepper was developed by the New Mexico Station using P.I. 288961 as one of the parents in the cross.

A trefoil cultivar, 'Kalo', was selected from P.I. 234670 and released by the Oregon Station.

SUMMARY OF PLANT GERMPLASM
INTRODUCTION AND USE
1977

Principal Centers:

Office of Plant Introduction,
Beltsville, MD
Foreign Exchange

Introduced: 6,651 Sent Abroad: 95,716

National Seed Storage Lab.,
Fort Collins, CO
Base Collection, Long-term
Storage

In: 3,174 To Users: 3,379

Working (Active) Collections:

Regional Plant Introduction
Station, Experiment, GA

In: 3,200 To Users: 20,856

Regional Plant Introduction
Station, Ames, IA

In: 450 To Users: 18,000

Regional Plant Introduction
Station, Geneva, NY

In: 900 To Users: 5,663

Regional Plant Introduction
Station, Pullman, WA

In: 1,140 To Users: 11,258

Small Grains Collection,
Beltsville, MD

In: 2,633 To Users: 176,326

Technological Objective 2.

New and improved knowledge of the chemical, biological, and agronomic potentials of selected plant species as new crop sources of industrial oils, waxes, gums, fibers, of food and feed proteins, and licit and illicit narcotic drugs and other medicinals.

Research Locations:

5502	Flagstaff, Arizona
7705	Savannah, Georgia
0710	Bloomington, Indiana
3102	Peoria, Illinois
3408	Ames, Iowa
0709	Rehovot, Israel
1103	Beltsville, Maryland
1108	Beltsville, Maryland
0203	Islamabad, Pakistan
1402	Philadelphia, Pennsylvania
7617	Mayaguez, Puerto Rico
0709	Chiang Mai, Thailand
0709	Ankara, Turkey
5502	Pullman, Washington

Selected Examples of Recent Progress:

Greenhouse and field evaluation of kenaf for root-knot resistance - Savannah, GA. Progeny of 59 kenaf selections from 1976 greenhouse screening were evaluated in the field nursery. Of the recently introduced material, 23 selections were made, but 3 from W75-34 were outstanding.

Evaluation of yield and plant characteristics of kenaf at high populations - Savannah, GA. Kenaf yield tends to increase with population to a population level of 600,000 plants per hectare. However a reversal of the trend occurred at a level of 740,000 plants per hectare. Plant size is reduced by increasing population levels throughout the tested range.

Fractionation of "confirmed actives" - Peoria IL. Refinement of the active principle of Sesbania drummondii has resulted in isolation of a high melting crystalline compound, believed from its NMR spectra to be an aromatic alkaloid. Fractionation of Cephalotaxus mannii has resulted in two compounds that appear to be active in an experimental leukemia system. These compounds are taxane derivatives and are structurally unrelated to harringtonine and related active compounds characteristic of most Cephalotaxus species. Fractionation of Trevis nudiflora has enriched the activity severalfold, and has given fractions with pesticidal activity as well as the customary PS (leukemia) and KB (cell culture) systems.

Develop seeds of Brassica cultivars with low glucosinolate content and high erucic acid content - Peoria, IL. The Brassica with the highest oil percentage was 50.9 with an erucic content of 59.6%. An F₁ plant from Bronowski x Gorczanski x S69-914 cross had 59.6% erucic acid, 45.4% oil, and only 1.5% glucosinolates. From 149 individual, F₅ B. napus plants

(Bronowski x Gorczanski) had 41% oil, 58% erucic, and 0.9% glucosinolates. Of the B. campestris samples, high values of oil and erucic acid content could be achieved, but no low glucosinolate accessions were found.

Synthesis of harringtonine - Peoria, IL. A synthetic procedure was developed for converting cephalotaxine, an inactive alkaloid from Cephalotaxus, to harringtonine, which is a potent antileukemic in experimental systems. This procedure makes use of an indirect route that avoids difficulties that thwarted this conversion, both in our laboratory and elsewhere. This development will help to make harringtonine available for clinical testing which has been delayed because of the scarcity of harringtonine from natural sources.

Screening of plants for preliminary anticancer activity - Beltsville, MD.

Screening of plants for preliminary anticancer activity yielded 268 new samples with confirmed anticancer activity; six merited high priority ratings and 72 medium priority ratings based on the activity against mouse lymphocytic leukemia P388.

Renewable source of maytansine discovered - Beltsville, MD. Maytansine, the most promising higher-plant anticancer agent identified by the screening program is now in Phase II clinical evaluation to determine if the new drug is clinically active against evaluable fast and slow growing tumors. The principal source of maytansine has been the stems of Maytenus buchananii from Kenya, but the number of areas where the plant is abundant is rapidly diminishing. Investigations of related species revealed that M. rothiana, an Indian species, is a superior source of the compound. Maytansine is concentrated in the seed, and since M. rothiana is a heavy seeder, it represents a renewable source of this valuable new drug. Also maytansine has been found to occur in Maytenus boaria, a widespread South American species distantly related to the African and Indian species currently the best sources of the compound. Although the yield of maytansine is comparatively low, this discovery suggests that the compound may be more widely distributed in the genus than previously believed. Hence, an even better source of maytansine may exist among the New World species of Maytenus. Additionally, we have identified an important source of raw material in the event other Old World sources become unavailable.

Year-round mini garden devised - Mayaguez, PR. A circular vegetable garden 20 feet in diameter has been devised to maximize year-round food production in home gardens of the hot, humid tropics. The garden requires no purchased inputs of fertilizer or pesticide, but relies on composting and manure for fertility, and resistant varieties for disease and pest control. Vegetables used were selected also for high nutrient value. The garden has been shown to produce more vegetables than a family can use.

Technological Objective 3.

Increased understanding of the taxonomic relationships, geographical and ecological distribution, and centers of diversity of crop plants and their wild relatives to promote the systematic assembly of germplasm for crop improvement.

Research Locations:

1108	Beltsville, Maryland
1211	Washington, D.C.

Selected Examples of Recent Progress:

Nomenclature manual released - Beltsville, MD. A manual containing the most up-to-date and accurate common names available for 3000 economic plants was issued. Containing many common names also, this manual will be invaluable to scientists, and their technicians and secretaries, in assigning correct modern nomenclature to plants in manuscripts and correspondence.

Agricultural potential of Dominican Republic mapped - Beltsville, MD. Following field work by multi-disciplinary teams of agronomists, economists, plant taxonomists, and soil taxonomists, the Dominican Republic was mapped according to Resource Production Units, i.e., units of sufficiently similar climates and soils that their agricultural potentials are rather homogeneous.

Flexibility of computerized climatic mapping demonstrated - Beltsville, MD. Having acquired monthly climatic data from more than 20,000 stations around the world, the Plant Taxonomy Laboratory can now, in collaboration with DSAD, generate maps of isotherms, isohyets, or superpositions of the two, resulting in ecosystematic life zones. These computer-generated broad-brush maps can then serve as "first drafts" for ground truth corrections. Tests run on Japan and Mexico show that such maps can be run off rather easily.

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National Research Program 20170

PHYSIOLOGICAL AND BIOCHEMICAL TECHNOLOGY TO IMPROVE CROP PRODUCTION

This National Research Program involves research which will yield data that will elucidate the basic function of plants at the physiological and biochemical level. This new data will help establish advanced agricultural technology with emphasis on field and horticultural crops. The major emphasis of the National Research Program is:

- a. to improve the photosynthetic capability, photosynthetic efficiency, translocation, metabolism, and biological conversion of solar energy by plants;
- b. to develop improved efficiency of nitrogen fixation and the absorption, translocation, and utilization of nutrients;
- c. to improve crop production under environmental stress and reduce stress damage to plants; and
- d. to improve technologies for understanding water relations, seed germination, growth regulation, flowering, fruiting, and photoperiod as a base for using molecular biology to increase crop production efficiency.

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Technological Objective 1.

Improve biological conversion of solar energy for increased crop production by increasing the efficiency of photosynthesis, translocation, and associated metabolism.

Research Locations:

7902	Athens, Georgia
3102	Peoria, Illinois
1109	Beltsville, Maryland
7502	Mississippi State, Mississippi
7802	Raleigh, North Carolina

Selected Examples of Recent Progress:

Complete cell separation and intracellular localization of photosynthetic enzymes in *Arundinella hirta* - Athens, GA. *A. hirta* L. is a C₄ plant having an unusual C₄ leaf anatomy. Besides mesophyll and bundle sheath cells, *A. hirta* leaves have specialized parenchyma cells which look morphologically like bundle sheath cells but which lack vascular connections and are located between veins, running parallel to them. Activities of photosynthetic

carboxylating enzymes (PEP and RuDP carboxylases) and decarboxylating enzymes (PEP carboxykinase, NADP- and NAD-malic enzymes) were determined for whole leaf extracts and isolated mesophyll protoplasts, specialized parenchyma cells, and bundle sheath cells. The data indicate that A. hirta is a NADP-malic enzyme type C₄ species. In addition, specialized parenchyma cells and bundle sheath cells are enzymatically alike. Compartmentation of enzymes followed the C₄ pattern with PEP carboxylase being restricted to mesophyll cells while RuDP carboxylase and decarboxylating enzymes were restricted to bundle sheath and specialized parenchyma cells.

Approximately ten *Panicum* species introduced from South America were characterized enzymatically for PEP carboxylase, RuDP carboxylase, NADP-malic enzyme, NAD-malic enzyme, and PEP kinase - Athens, GA. Control plants were tall fescue, C₃, P. maximum, C₄, and P. milioides, intermediate C₃-C₄. Six new *Panicum* species introduced from South America by Dr. H. Brown were also examined: P. rivulare, P. schneckii, P. prionitis, P. hylaeicum, P. decipiens, and P. laxum. Enzyme activities were determined using duplicate whole leaf extracts and were expressed on a chlorophyll basis. P. prionitis was found to be a NADP-malic type C₄ plant species. Of the C₃ plant species the ratio of RuDP carboxylase activity to PEP carboxylase activity was lowest for P. milioides, P. schneckii, and P. decipiens. These 3 plant species also had the highest activities of decarboxylating enzymes even though the enzyme activities were much lower than normal for a C₄ plant species. CO₂ compensation values and photosynthetic rates under low and high O₂, indicate that P. schneckii and P. decipiens are indeed C₃-C₄ intermediate plants.

Identify specific carotenoid pigment sensitizers of photosynthesis by quantum efficiency measurements on species from algal families and on higher plants in order to advise plant breeders of how to modify crop plants for higher light absorption and efficiency - Peoria, IL. Equipment for simultaneously measuring oxygen evolution, incident, transmitted and/or fluorescence light has been constructed. It incorporates Ulbricht spheres to correct for scattered light and thus can potentially measure absolute quantum efficiencies of oxygen evolution and of fluorescence in strongly light-scattering biological systems. This equipment is placed on-line to the computer for measuring action spectra of variously pigmented algae, chloroplasts suspensions, and plant cells, particularly in the region of carotenoid absorption. The individual system components, including a dye tunable laser and an Argon ion laser, are operational and the assembled system is being tested. Variation in pigment composition of chloroplasts of the yellow isolines of Harosoy and Clark soybeans has been studied throughout the growing season and a correlation between Chlorophyll a to b ratios and Chlorophyll a to carotenoid pigments has been found. These changes appear to be a function of the amount of grana stacking in the chloroplast.

In green plant photosynthesis, two photoreactions are involved, one which oxidizes water to produce oxygen (Photosystem II) and the other which reduces carbon dioxide to produce carbohydrates (Photosystem I). These photoreactions are connected by a movement of charge. A flash polarographic

method was used to monitor this charge movement by detecting the production of superoxide (O_2^-). This method should allow better understanding of the control of electron flow between Photosystems I and II.

The effect of temperature of the decay of delayed light emission following a single, saturating, 10 ns, excitation flash (337 nm) was investigated in cooperative studies with the University of Illinois. Measurements were made on chloroplasts isolated from leaves of peas, lettuce, beans, and spinach over a 0 to 35 C range. Decay of delayed light in the 6 to 120 μ s range was insensitive to temperature, whereas in the 120 to 340 μ s range it was temperature sensitive. With spinach and bean chloroplasts, Arrhenius plots of the delayed light decay rate constant had discontinuities in temperature. Temperature sensitivity of delayed light decay is believed to reflect a charge stabilization involving a lipophilic quinone molecule which is the primary electron acceptor of Photosystem II in green plants.

Study photorespiration in the presence of photosynthesis in order to reduce loss of efficiency caused by photorespiration - Peoria, IL and Urbana, IL. A Bendix Time-of-Flight mass spectrometer has been modified for monitoring oxygen isotopes and carbon isotopes of carbon dioxide simultaneously. Significant improvements in instrument sensitivity have been made. An irradiation cell for algae has been constructed bearing a Clark electrode at the top (oxygen diffusion through a Teflon film) and a Teflon membrane at the bottom through which analytical amounts of oxygen, carbon dioxide, and other gases diffuse into the source area of the mass spectrometer. Oxygen evolution during photosynthesis and oxygen consumption during dark respiration from *Chlorella* have been thus measured and compared. A mass scanning procedure of analysis has been found more accurate than mass monitoring.

Studies on the mechanism and efficiency of energy transfer from carotenoid to chlorophyll molecules in carotenoid-chlorophyll-protein systems isolated from plant sources and those synthesized from individual purified pigment components - Peoria, IL. Using a fluorescence probe to measure energy transfer from carotenoid to chlorophyll-a molecules, it has been demonstrated by action spectra (excitation spectra) that transfer takes place both in intact *Phaeodactylum tricornutum*, and in its isolated cell-membrane-material which was obtained by careful disintegration of cells. Recently, it was found that membrane-material treated with a fatty acid type detergent and then centrifuged at 144,000 xg gave supernatants that exhibited very good energy transfer properties. Carotenoid-chlorophyll-protein complexes (light harvesting pigment complexes) isolated in earlier work by sonification (20 khz) and Triton X-100 treatment were shown to have a molecular weight of 26,000 and to contain a carotenoid (fucoxanthin), chlorophyll-a molar ratio of at least 3. Isolation of "active" fucoxanthin-chlorophyll-a-protein complexes have not previously been reported.

Characterize the physiological and morphological development and the photosynthate partitioning patterns for sugarbeet seedlings - Beltsville, MD. A comparison of the development of fibrous and taproots of plants with low and high taproot-leaf weight ratio (TLWR) was investigated. Comparison of the ratio of the fibrous roots to taproot and the ratio of the fibrous

roots to the leaf blade weight of a number of breeding lines at 21 days from emergence may be a criteria for selection of higher performance sugarbeet lines. Low TLWR sugarbeet plants grown in fine sand (0.5 mm) had ratios of fibrous roots to leaf blade weight about 40% greater than those grown in vermiculite with the same mineral nutrition. TLWR was not altered significantly. Two populations that differed by 65% partitioning to the taproot-hypocotyl at 21 days post-emergence in the growth chamber were selected from a sugarbeet breeding line and grown in the field. The population that partitioned more photosynthate to the taproot-hypocotyl yielded 73.7 mt/ha; whereas, the population that partitioned less yielded 60.3 mt/ha. The differential in partitioning between the two populations at the end of the growing season was 26%; the yield differential was 22%. The high-partitioning population had significantly higher sucrose content than the low population (15.9% versus 14.5%). The high population produced 35% more extractable sugar per acre than the low population; 22% more than the unselected population; and 2% less than the presently grown commercial hybrid. Taproot weight over the growing season does not correlate highly with TLWR. Thus, selection for both taproot weight and TLWR would be required to maximize yield.

Metabolic factors that control the partitioning and translocation of carbon and carbon assimilates in leaves have been identified - Beltsville, MD. Diurnal carbon dioxide exchange rates, starch, sucrose, chlorophyll, and soluble protein levels were among the parameters studied during the development of second trifoliolate soybean leaves. Leaves that are approximately half expanded fix more carbon dioxide per unit dry weight than fully expanded leaves, but contain 10% less soluble protein and 50% less chlorophyll per unit dry weight. Chlorophyll and protein levels increase beyond full leaf expansion but are not accompanied by increases in carbon dioxide exchange rate. Starch content on a dry weight basis did not change during leaf expansion. However, energy and synthetic demands changed considerably, suggesting that starch accumulation in the test leaf is not controlled entirely by the energy demands within that leaf. Sucrose phosphate synthetase activity and sucrose levels were positively correlated with increasing translocation rates during leaf expansion. However, following full leaf expansion, translocation rates declined while sucrose and sucrose phosphate synthetase activity remained unchanged. These studies have established an ontogenetic frame of reference for future studies, and have identified a number of components that may limit carbon assimilation and partitioning in soybean leaves.

Metabolic factors that control the partitioning and translocation of carbon assimilates between two vegetative centers of assimilate demand have been identified - Beltsville, MD. The cellular distribution of sucrose in sugarbeet taproot tissue has been correlated with TLWR (taproot-leaf weight ratio) and is independent of taproot fresh weight and total sucrose content. Percentage of total sucrose found in the storage compartment (vacuole) increased, but that in the cytoplasmic compartment decreased as TLWR increased. This relationship may be an expression of a greater sucrose-mobilizing capacity of high TLWR taproots, resulting in a greater retention of assimilates in the taproot relative to the fibrous roots.

Higher in vitro acid invertase activity was measured in taproots of low TLWR versus high TLWR plants at 21 days post-emergence. Alkaline invertase and sucrose synthetase activities in 21-day taproots do not differ with TLWR. Acid invertase activity in taproots decreases from 14 to 28 days post-emergence and during this period, sucrose storage begins. Thus, both genetically and ontogenetically, acid invertase activity appears to be inversely related to development of the storage organ. Acid invertase may control cellular sucrose distribution, which in turn influences cellular growth and differentiation (e.g., lateral root intitiation from the taproot).

The variation in chlorophyll, total nitrogen, protein nitrogen, and free amino acids in senescing and aging cotyledons has been determined - Mississippi State, MS. An experimental technique was used to delay senescence so that comparisons could be made between senescing and non-senescing cotyledons of the same age and while still attached. By removing all apical growth, cotyledons lived longer and eventually died by a process different from senescence. These are referred to as "aging" cotyledons. The important difference between the cotyledons, comparing "aging" to senescing were: 1) prolonged life, 2) retention of chlorophyll, 3) less dramatic loss of protein and total nitrogen, and 4) retention of free amino acids. The retention of amino acids reflects a tendency for protein breakdown in aging cotyledons, but no sink for transport. Buffer extracts of both kinds of cotyledons contained a number of peptidases but no endoproteases. The variation in peptidase activity between ages and the two kinds was insignificant to attribute a regulatory role to these enzymes. However, if in future work no endopeptidase activity is found, there is a reasonable model to account for protein breakdown in senescing cotyledons and no breakdown in aging ones.

Investigations to improve biological conversion of solar energy for increased crop production by increasing the efficiency of photosynthesis, translocation, and associated metabolism - Raleigh, NC. Factors involved in the regulation of photosynthesis have been studied in vitro with intact chloroplasts isolated from spinach, barley, and tobacco. Photosynthesis was inhibited by excess inorganic phosphate (Pi) because of the loss of photosynthetic intermediates from the chloroplast. The relative inhibition by Pi was enhanced by sub-optimal pH and low concentrations of divalent cations. It was determined that the pH of the chloroplast stroma controls the rate of CO₂ fixation and inhibition by exogenous Pi. High concentrations of Pi or low concentrations of Pi plus magnesium completely inhibited oxygen evolution by preventing the light-activation of the Calvin cycle enzymes NADP-glyceraldehyde-3-P dehydrogenase, phosphoribulokinase, and fructose-1,6-bisphosphatase. The results suggest that in vivo, changes in the cytoplasmic pH and concentration of magnesium may control sucrose synthesis by regulating the efflux of carbon skeletons from the chloroplast.

Technological Objective 2.

Improve nitrogen fixation efficiency of bacteria-plant associations and develop nitrogen-fixing capabilities in crops lacking this capability in order to reduce energy requirements for crop production.

Research Locations:

5102	Albany, California
7602	Gainesville, Florida
3102	Peoria, Illinois
1109	Beltsville, Maryland
7802	Raleigh, North Carolina

Selected Examples of Recent Progress:

Investigations to determine the growth regulators produced by nitrogen-fixing bacteria found in the rhizosphere of forage grasses - Gainesville, FL. Chromatographic and bioassay procedures were used to separate and identify plant growth substances produced by soil bacteria in liquid culture. When ethyl acetate extracts from basic and acidic fractions from 5 cultures were assayed, indole acetic acid (IAA) was identified in 4 of the cultures. Lettuce hypocotyls were used to identify gibberellin activity, and radish cotyledons to identify cytokinin activity. IAA was found in amounts from 0.2 µg/ml (Azotobacter paspali) to 6.2 µg/ml (Azospirillum brasilense). Bioassays showed the presence of cytokinin activity in all cultures, but chromatographic data indicated that neither zeatin or kinetin was present. Experiments to detect gibberellins were conducted with only one of the bacterial strains, Azospirillum brasilense.

Evaluation of plant genotype responses to root zone inoculation with Spirillum lipoferum and other nitrogen-fixing organisms - Gainesville, FL. Nutritional regimes and other environmental effects were found more influential than genetic differences among grass species tested, in determining the character and qualities of root exudates. No evidence has been found to indicate that Azospirillum spp. (formerly Spirillum lipoferum) achieves a relationship with grass roots unlike that of other free living rhizosphere organisms. Various strains of Azospirillum survive following inoculation to the rhizosphere, but they do not dominate the microbiological population nor do they utilize the greatest part of the substrate made available in the soil by plant root activity.

When the oxygen content of nitrogen-depleted soils was reduced, utilization of added substrates by nitrogen-fixing organisms increased rapidly. Various inoculation techniques failed to establish Azospirillum spp. as the dominant nitrogen-fixing organism, and the experimental results suggest that this cannot be achieved. Nitrogen fixation rates can be increased by addition of various carbon sources but Azotobacter spp. maintain dominance even when the added substrate is an organic acid which should favor growth of Azospirillum.

Investigations to elucidate the physiology of the individual partners of the plant-algal symbiosis and attempt to recombine them into an effective nitrogen-fixing plant - Peoria, IL. Rates of growth, nitrogen fixation, levels of glutamine synthetase activity, and response of nitrogen fixation to inhibitors and growth conditions have been studied to compare blue-green algae derived from Azolla with similar free-living algae. In general., algae derived from Azolla are similar to other Anabaena, but appear somewhat more heterotrophic in their metabolism.

The algal-plant nitrogen-fixing symbiosis has been shown to correlate with the presence of specific proteins - Peoria, IL. By using the sodium dodecyl sulfate-polyacrylamide gel electrophoresis, a survey was made of plant proteins isolated from algal-containing nitrogen-fixing plants. A high-molecular weight protein characteristic of the association was detected and is being characterized.

Investigations of the nitrogen-fixing symbiosis between the water fern, Azolla, and its associated blue-green algae - Peoria, IL. Two bacteria have been found associated with the algae (Alcaligenes faecalis and Caulobacter sp., along with a heavy contamination with amoebae and fungi. Surface sterilization with hypochlorite and treatment with the antifungals Amphotericin B and cycloheximide were ineffective. In order to better study the algal-fern symbiosis, it is necessary to remove these contaminants from the Azolla fern. Methodology is being developed for the culturing of Azolla callus tissues and these materials are being investigated concerning their response to various tissue culture ingredients on growth of the isolated alga. Preliminary observations suggest that the alga is sensitive to some plant hormones.

Investigations to isolate rhizobial capsular polysaccharides and determine their composition and structures in order to determine their relationship with the symbiosis infection process - Peoria, IL. Two Rhizobium spp. NRRL B-4384 (from black wattle) and B-4386 (from purple clover) developed extensive capsular polysaccharides when grown on a yeast extract-mannitol-soil extract medium. A technique has been devised to isolate the capsular material. The polysaccharides (PS) were shown to be quite different. Neutral sugar components of PS B-4386 were D-mannose, glucose, and galactose in approximate respective molar ratio 1:2.5:2. PS B-4384 contained an unidentified methylpentose in addition to L-rhamnose, D-mannose, D-glucose, and D-galacturonic acid. Reduction of PS B-4384 carboxyls permitted 1) complete hydrolysis and determination of component ratios by gas-liquid chromatography as peracetylated aldononitriles and 2) confirmatory identification of the uronic acid component through its conversion to galactose. Accordingly, the approximate molar ratios of galacturonic acid:unknown methyl pentose:rhamnose:mannose:glucose were 1:1.5:3:3.5. The reduced PS B-4384 has been permethylated for structural analysis.

Investigations to determine whether field inoculation of cereal crops with associative nitrogen-fixing bacteria promotes nitrogen fixation and agronomic yield - Beltsville, MD. Acetylene reduction activity of soil root cores averaged 2 moles ethylene per core per hour and ranged from 0 to 45 units during rapid growth stages. The activity was not influenced by crop species, nitrogen, or bacterial treatments. The number of nitrogen-fixing S. lipoferum

washed from roots was about 10^4 bacteria per gram dry roots and not influenced by treatments. Dry matter production and total nitrogen in plants were significantly increased by fertilizer nitrogen but not influenced by bacterial inoculation. Numerous mutant S. lipoferum strains with multiple drug resistance markers have been isolated and can be unambiguously determined on corn roots in soil after inoculating seeds with these strains. Maize and pearl millet were inoculated with nitrogen-fixing bacteria and grown in ^{15}N -labeled soil in the field. No dry matter yield response from inoculation was found. The ^{15}N analyses are being performed.

Investigations using R. japonicum and modern microbial genetics has resulted in techniques for genetic hybridization of R. japonicum, selection of Rhizobium mutants with enhanced glucose utilization, and a technology to evaluate the introduction of R. japonicum inoculum into soils populated with indigenous R. japonicum - Beltsville, MD. Potential sex factor plasmids R1822 and pRD1 were transferred to R. japonicum from Pseudomonas aeruginosa and Escherichia coli. The transfer of the introduced plasmids between genetically marked R. japonicum strains was demonstrated. Optimum conditions for R factor transfer were determined. Rhizobium mutants were screened for enhanced glucose utilization. Mutants which grew with an apparent generation time of 11 hours instead of 18 hours were isolated. The methodology for the chemical mutagenesis of R. japonicum and screening survivors for mutants has been developed. In order to measure the competitiveness of hybrid R. japonicum strains and inoculum in the native soils populated with R. japonicum, genetically marked strains have been prepared. A strain carrying genetic markers for azide, rifampicin, and streptomycin resistance was constructed. This strain was examined for introducibility into a soybean field heavily populated with Rhizobium. Examination of nodules for the genetic markers was found to be an unambiguous determination of the inoculum strain.

Isolation of spontaneous mutant strains of R. japonicum strain I-110 - Raleigh, NC. Although strain I-110 does not normally nodulate non-nodulated soybean plants, it was thought that cultures of strain I-110 might contain rare spontaneous mutant cells which would be able to nodulate these plants. This line of non-nodulated soybean plants was inoculated with heavy cell suspensions of R. japonicum strain I-110. After 5 weeks of growth, a few of the plants had 1 or 2 extremely large nodules. Reisolation of the strains contained in these nodules and subsequent nodulation tests showed, however, that these strains did not nodulate non-nodulated plants any better than the parent I-110 strain.

Analysis of hybrid transformants from crosses between Rhizobium and Azotobacter vinelandii - Raleigh, NC. Increasing evidence suggests that O-antigens present on the cell surface of R. japonicum may be involved in the establishment of a nitrogen-fixing symbiosis between this bacterium and soybean plants. It can be hypothesized that the O-antigen may be important for the initial binding of R. japonicum to soybean root hairs. Thus, it is possible that a hybrid strain of A. vinelandii which carries

R. japonicum O-antigens might suppress nodulation when mixed with R. japonicum. Therefore, an experiment was conducted in which soybean plants were inoculated with mixtures of several different strains of A. vinelandii and a single strain of R. japonicum. Unexpectedly, all of the A. vinelandii strains tested, including the hybrid strain carrying rhizobial O-antigens, enhanced nodulation. The greatest enhancement was a 2.5 fold increase over nodulation by R. japonicum alone. The hybrid A. vinelandii strain, however, gave the least amount of enhancement. This suggests that a competitive effect may have been superimposed on the enhancement effect by this strain.

Nitrogen-fixing (Nif^+) hybrid transformants resulting from crosses between R. trifolii or R. japonicum and a mutant strain of A. vinelandii, unable to fix N_2 (Nif^-), were analyzed for the presence of nitrogenase proteins, altered in charge and/or molecular weight. The 2 subunits of the Mo-Fe protein of nitrogenase were found to be altered in an identical fashion in all of the hybrid transformants tested. It was first thought that these altered proteins might be of rhizobial origin; however, some Nif^+ revertants of the Nif^- A. vinelandii recipient contained Mo-Fe protein subunits which appeared to be identical to the subunits found in the hybrid transformants. At this time it is unclear as to whether the Nif^+ hybrid transformants are carrying rhizobial genes coding for nitrogenase or whether they have become Nif^+ due to a reversion event.

Investigations to elucidate the relationship between seed yield and the balance of carbon-nitrogen nutrition during soybean development - Raleigh, NC. Integration of seasonal acetylene (C_2H_2) reduction profiles of intact soybean growing in minus nitrogen culture medium resulted in a 60% under estimation of the actual amount of nitrogen fixed. C_2H_2 reduction rates declined by as much as 60% within 30 minutes of shoot removal indicating the requirement of concurrent photosynthate transport to nodules to sustain maximal nitrogen-fixing activity. Results suggest caution in using C_2H_2 reduction assays to predict seasonal nitrogen fixation. Patterns of nitrogen fixation rate based on C_2H_2 reduction assays and on total nitrogen accumulation indicate that a high rate of nitrogen fixation was sustained into the latter stage of podfill. Partitioning of dry matter and nitrogen to reproductive tissue was the same as that reported for field plants. Thus, decline in nitrogen fixation rate reported for field plants in early to mid podfill may be related to factors other than photosynthate supply. Nitrogen fixation was capable of meeting at least 75% of the requirement for maximal seed yield when soybeans were nodulated by an efficient bacterium (R. japonicum 110). The yield advantage of plants supported by both nitrogen fixation and nitrate assimilation resulted from enhancement of early growth before nodules became fully functional. Xylem sap of nodulated soybeans was shown to contain allantoin and allantoic acid and a 6-fold excess of inorganic cations relative to inorganic anions. Allantoin and allantoic acid and organic acid anions may be important nitrogen transport forms and counterions, respectively, in the xylem sap.

Technological Objective 3.

Develop new and improved cell and tissue culture technology for plant improvement through increased genetic diversity and rapid vegetative propagation.

Research Locations:

3102	Peoria, Illinois
1109	Beltsville, Maryland
3507	Madison, Wisconsin

Selected Examples of Recent Progress:

Antitumor alkaloids--Investigations to develop technology for the production of *Cephalotaxus harringtonia* - Peoria, IL. Initial studies showed that preharvest changes in the tree are more important than post-harvest changes for the production of the antitumor alkaloids. Trees sampled during the season of rapid growth contained no detectable alkaloid esters, but large amounts of the alkaloid, cephalotaxine, and its oxidation products. Topping a laboratory-grown plant to force regrowth produced a similar alkaloid pattern showing that stored alkaloid esters were hydrolyzed to the free alkaloid during periods of rapid growth. Under such conditions, the alkaloid pattern observed in the tree resembles that found in tissue culture. Cell cultures of *C. harringtonia* were further propagated in liquid suspension culture and several cell culture lines were isolated. Studies to develop a culture medium that would enhance the growth rate of *C. harringtonia* cells tested cobalt, molybdenum, boron, zinc, iron (EDTA), manganese, copper, and iodine. A highly significant effect was found for cobalt and molybdenum on both fresh tissue weight and dry weight. The balance of these 2 minerals in the medium was shown to be critical for cell proliferation. These cell cultures will be used to investigate the biosynthesis of the antitumor alkaloid, cephalotaxine.

Rice and tobacco (Susu) cell culture systems were developed to investigate differences in their protein nutritive quality - Beltsville, MD. Previous work established that Susu/tobacco can be successfully cultured in liquid medium and successfully plated on solid agar to produce regenerating tissue. This is the second step in using this cell type as a marker. Also, rice cells have been successfully cultured in liquid suspension. These cells were specifically selected for amino acid analog resistance. These cells grow well in liquid suspension in the presence or absence of the analog inhibitor. Previous work provided 25 lines of rice resistant to S-aminoethylcysteine. Three lines have been differentiated into plants from which seeds were obtained and progeny analyses are in progress.

Quantitative analyses of amino acids from cells selected against amino acid analogs were made. Plants which were regenerated from cells resistant to S-aminoethylcysteine have been selfed. Seeds from first generation plants and seeds from 9 second generation plants show variable amino acid

levels. The genetic characters segregate more extensively than anticipated; however, the method permits the selection of plants with elevated levels of free and protein amino acids in their seeds.

Uptake and expression of foreign genomes by plant protoplasts - Beltsville, MD. A plant protoplast culture system was developed for testing the phenotypic expression of foreign DNA taken up by the cell. Recombinant DNA, cloned and isolated from E. coli, was taken up by the plant protoplasts. Plants were regenerated and viable seed produced; but, the marker gene for antibiotic resistance was not expressed in the eukaryotic test system.

Differentiation of tissue cultures from crop plants - Madison, WI. Tissues from several varieties each of corn, potato and soybean, as well as 13 species of Nicotiana, have been placed in culture. Shoots have been obtained from potato, N. tabacum, N. acuminata, N. plumbaginifolia, N. goodspeedii, N. megalosiphon, N. suaveolens. Detailed tests of environmental conditions (light and temperature), medium addenda (hormones, sugars, salts) and of various cultivars of corn, potato, soybean, and Nicotiana sp. will be conducted in order to develop procedures for differentiating cells.

Agrobacterium tumefaciens plasmid as a vehicle for the transfer of new genetic information - Madison, WI. The Agrobacterium tumefaciens Ti plasmid was digested with various restriction endonucleases, and several hydrolysis fragments cloned in E. coli. The fragments chosen for cloning were all within that portion of the Ti plasmid that is transferred to the plant during tumorigenesis. These cloned fragments are being used to genetically map the plasmid in the transfer area. Once mapped it will be determined how much of the transferred area is transcribed in the plant. This approach involves purifying radioactive m-RNA from tumor tissue and hybridizing it to individual plasmid fragments. Both silent and active areas will be tested for their ability to initiate RNA polymerase activity.

Technological Objective 4.

Develop technology for improving the absorption, translocation, and utilization of nutrients and water to increase crop production efficiency.

Activities under this technological objective are being implemented. This research is presently being conducted in part under NRP's 20010, 20100, 20730, 20760, 20770, 20780, and 20790.

Technological Objective 5.

Improve technology for better crop production under environmental stress.

Research Locations:

7602 Gainesville, Florida
1109 Beltsville, Maryland

Selected Examples of Recent Progress:

Determine physiological, biochemical and ultrastructural effects of UV-B radiation on crops - Gainesville, FL. Investigations of possible effects of UV-B radiation (280-320 nm) on "Bragg" and "Altona" soybeans, "Little Marvel" peas, "Rutgers" tomatoes, and "Golden Cross Bantam" sweet corn were carried out under greenhouse conditions. In soybeans, peas, and tomatoes (C_3 plants) exposure to UV-B caused significant depressions in biomass accumulation, photosynthetic pigment contents, and leaf CO_2 uptake rates. Leaf pigment extracts in 80% aqueous acetone from UV-B-treated plants of soybeans and peas showed considerable increase in absorption in the wavelength region 330 nm - 400 nm with increased UV-B doses. Hill reaction measurements with chloroplast preparations of both soybeans and tomatoes showed significant reduction when seedlings were exposed to 2.25 UV-B_{seu}. Significant inhibitions of RuDP-Carboxylase were obtained in soybean leaf extracts at all UV-B doses. An apparent decrease in soluble proteins was also observed in soybean leaf extract while higher levels of proteins were present in UV-B-treated tomato leaves.

In sweet corn (C_4 plant), seedlings exposed to UV-B had significant lower biomass accumulation than those of the controls. Plant height and leaf area gradually decreased with increasing levels of UV-B radiation. Only corn seedlings exposed to the highest treatment showed significant inhibition in leaf photosynthetic rates. Activities of PEP-Carboxylase in crude extracts from corn leaves were significantly suppressed under the two highest UV-B doses. No difference in proteins among treatments and controls were detected. These studies were conducted at 1.3 to 2.3 times the normal UV-B sun equivalent and under greenhouse growth conditions.

Investigations have been made to study the chemical modification of plant membranes in relation to stress responses - Beltsville, MD. To extend knowledge of substituted pyridazinones effect on lipid metabolism, membrane lipid make-up, stored seed lipid, and on stress resistance, a series (49 total) of related pyridazinones were screened for ability to alter wheat root lipid and cold resistance. The data indicate the pyridazinone molecular sites responsible for lipid altering activity. A series of compounds was found that varies quantitatively in its ability to reduce linolenic acid synthesis. They were tested for correlative ability to alter freezing hardness in wheat and chilling tolerance in cotton. Field experiments with barley, rye, and two wheat varieties are in several levels. Wheat leaf lipid analysis for reduced linolenic acid has correlated well with winter kill. Survivors, especially of high dosage treatments, will

be retained to ascertain resistance to the pyridazinones and resistance to freezing by alternate lipid synthetic pathways. Resistance to summer stress (heat or water deficit) was induced in Silver Queen sweet corn by soil incorporation of the same pyridazinone that reduces freezing and chilling resistance. Growth chamber studies indicated improved water economy by plants treated with this substituted pyridazinone.

Comparison of vegetative growth and leaf water potentials of pepper plants grown in three types of soils - Beltsville, MD. Thirty-two day-old seedlings were subjected to water stress in the growth chamber by withholding water for 0 to 5 days. Plants were rehydrated after 2, 4, or 5 days and comparative (pressure bomb) measurements made of leaf water potential, in addition to dry weight of tops and roots, leaf area, root/top ratio, and specific leaf weight. In general, for any one cultivar at any one harvest, vegetative growth as measured by dry weight of tops and roots and leaf area was greater in plants grown in a peat-vermiculite mix than the other two types of soil mix. Despite these large differences, when the data were expressed on the basis of root/top ratios and specific leaf weights, the values were amazingly constant. This suggests that plants have a unique ability of adapting to stress conditions by modifying both their shoot and and root development.

Increasing the period of water stress from 0 to 6 days significantly increased the percentage of dry matter of the tops formed in the stems and significantly decreased the percentage of dry matter formed in the fruits. There was no significant change in dry matter partitioning in the leaves. These findings provide some of the first evidence for persistence of water stress treatment effects at the juvenile stage on subsequent vegetative growth and reproductive development.

Biological effects of UV-B radiation on plant growth and function - Beltsville, MD. Greenhouse, growth chamber, laboratory, and field studies were conducted on a wide range of vegetable and agronomic crops to determine the relative sensitivity or resistance to increased UV-B radiation. Data were collected on various physiological responses to increased UV-B radiation including: photosynthesis, respiration, ion uptake, translocation of radioisotopes, stomatal activity, changes in chlorophyll and anthocyanin content, leaf movement, germination, seedling growth, and reproductive development. Studies were also conducted on UV-B interactions with disease organisms.

Dose-response Studies--Broad band UV-B studies were conducted in the greenhouse and growth chamber on over 20 species and cultivars of vegetable and agronomic crops. Plants were exposed to a gradient of UV-B radiation representing a 50 to 500% increase in biologically effective UV radiation. Plants studied included cotton, peanut, wheat, rice, alfalfa, cucumber, pea, beet, tomato, rutabaga, okra, bean, radish, and turnip. Most plants were exposed to UV-B for 4 to 5 weeks from time of planting the seed, but a few (wheat, rice, alfalfa, cotton) were grown to maturity under elevated UV-B. Visual injury was observed in over half of the species and cultivars studied. In most cases only slight or moderate UV damage was noted even when the plants were exposed to increases in the level of biologically effective UV radiation as high as 300 to 400%. The most dramatic evidence of UV-B injury was chlorosis in pea and cucumber, necrosis in pea leaves and pods, and reduction in leaf size in pea and cucumber.

Dose response studies conducted on cucumber varieties demonstrated significant differences in UV-B sensitivity; Poinsett cucumber was extremely sensitive and Ashly cucumber was only slightly sensitive. Evidence was obtained for UV-B induction of chlorosis of the leaves, inhibition of leaf enlargement and reduction in biomass. These effects were most pronounced under conditions of low photosynthetically active radiation and high UV-B exposure. High levels of UV-B irradiation in the greenhouse (100-400% increase in biologically effective UV) reduced total number of kernels in Pacific Triple Dwarf wheat by 20% but had no appreciable effect on average weight of grain.

Translocation of radioactive zinc from the cotyledons to other plant parts of the young cotton was not influenced by a 100-400% increase in biologically effective UV; however, the transport of radioactive calcium was depressed 12 to 30% over this range of UV irradiation.

Based on linear regression analysis of plant data obtained in the greenhouse on one of the most sensitive plants (Poinsett cucumber) exposed to increased UV irradiation (from 0 to over 300% increase in biologically effective UV) it was estimated that a maximum decrease in stratospheric ozone content of 20% would cause a 10% reduction in dry matter accumulation and a 15% decrease in leaf area. It is not possible at the present time to determine whether these estimates can be applied to other species of higher plants.

Field studies were conducted on UV effects at Beltsville on a range of agronomic and vegetable crops using a gradient of UV radiation. Crop plants studies included Contender bush bean, Early Prolific straightneck yellow squash, Amsoy-71 soybean, sugarbeet, Golden Cross Bantam corn, R-720 sorghum, and Waltham 29 broccoli. A fall crop of winter grains was also grown that included Potomac, Redcoat, and Abe wheat, Pennard and Monroe barley, and Abruzzi rye. Increasing the biologically effective UV radiation by 100% had no visible or consistent effect on crop performance under field conditions.

Plant Disease Interaction with UV-B Radiation-- The results of increased levels of UV-B irradiance on spore germination indicate that although plant leaf pathogenic fungal species vary considerably in sensitivity to UV-B, relatively high irradiance levels are required to reduce germination percentage. Pigmented spores such as Cladosporium, Stemphyllium, and Alternaria were found to be more resistant to increased UV-B irradiance than hyaline spores (Mycosphaerella Colletotrichum).

Disease severity of Colletotrichum lagenarium on cucumber was decreased with increasing UV-B irradiances. A linear decrease in the percentage of leaf area diseased with increased irradiances was found. Increased levels of UV-B irradiance did not affect disease severity of Cladosporium cucumerinum. The disease tended to reduce plant growth equally regardless of UV-B irradiance levels. There were no noticeable UV-B effects on either the Stemphyllium botryosum pathogen or the host, alfalfa.

Although these results represent only a small sampling of leaf disease organisms and of plant disease-interaction experiments, they appear to support the following conclusions: 1) Considerably higher levels of UV-B irradiances than those expected from the projected ozone depletion will be required to adversely affect germination and growth of pathogenic fungi. 2) Where fungal germination and growth are affected, disease severity in the host plant can be expected to be reduced as UV-B irradiances increase.

Technological Objective 6.

Develop new technology for control and regulation of biochemical, physical, and morphological processes of plants.

Research Locations:

1109 Beltsville, Maryland
1307 Ithaca, New York

Selected Examples of Recent Progress:

Data collected to characterize biochemical and physical properties of plasma membrane and identify site and mechanism of phytochrome action - Beltsville, MD. Fluorescein has been used as a chemical probe to identify a probable site of phytochrome action in the plasma membrane. Experiments show that both gravity and phytochrome quickly increases the flow of fluorescein in phloem cells of Mung bean hypocotyl segments. These results suggest that both of them could be acting on the same target which modulates growth responses. When Mung bean plants are grown without boron, the rapid increase in translocation brought about by phytochrome and gravity is absent or greatly reduced. Pretreating the hypocotyl segments of minus-boron plants with low concentrations of boron restores the rapid increase in fluorescein movement induced by phytochrome and gravity. It is postulated that both phytochrome and gravity act on the plasma membrane to generate a positive electrostatic charge. Phytochrome has been shown to increase the positive bioelectric potential of plant tissues. This charge is in some manner stabilized by boron. It was previously reported that interaction of boron with red light induces a rise in the positive bioelectric potential of mung bean hypocotyl segments. The positive charge increases the rate of flow of negatively charged growth substances into receptor cells. This quickly affects cellular growth and other physiological processes. Thus, a boron-containing complex in the plasma membrane could be the key to understanding the molecular mode of action of phytochrome.

Bioassay to monitor the chemical purification and biological activity of a harringtonolide from Cephalotaxus - Beltsville, MD. Harringtonolide, a substance isolated from Cephalotaxus, was evaluated to determine its effect on several types of plants. Preliminary data indicate that at a concentration of $10^{-4}M$ it is toxic to root meristems of grass species and that it will kill the terminal buds of Pinto bean plants. It appears to be very localized and is not translocated more than a few millimeters from the point of application. Harringtonolide inhibited root formation in the Mung bean bioassay at $1 \times 10^{-5}M$. Root formation was stimulated

by leaving the cuttings in the solution for up to 3 days, and then placing them in water to root. At $1 \times 10^{-4}M$, the chemical was phytotoxic.

Studies to elucidate the biological activity of camptothecin - Beltsville, MD. Results of competitive studies with gibberellin showed that GA_3 will not overcome inhibition by camptothecin, hence this new natural plant growth inhibitor is probably not an antigibberellin. This is supported by morphological data showing that the cell length in short plants is essentially equal to those in normal plants. The obvious darker green color in grass plants inhibited by camptothecin was related to increased chlorophyll as shown by spectrophotometer readings of alcoholic extracts. The thicker, shorter plants had twice the dry weight of untreated control plants when based on equal fresh weights. Microscopy data indicate that camptothecin has little if any effect on existing cells at the time of treatment but causes a cessation in the formation of new cells in the grass plants. The effect of camptothecin on cell differentiation was studied by rooting Mung bean cuttings in aqueous solutions of the chemical. Root differentiation was completely inhibited at $1 \times 10^{-6}M$ and above. Cuttings for the first 3 days in a $1 \times 10^{-6}M$ solution, then in water, initiated 100% more roots than cuttings in water all the time. They formed no roots if allowed to remain in this solution 5 or more days. Indoleacetic acid in a mole to mole ratio did not overcome the root inhibitory effect of the chemical. Camptothecin applied in lanolin to injured tissue of the Tempo bean inhibited the formation of plant tumors.

Develop bioassays for brassin - Beltsville, MD. Brassin activity was detected at concentrations as low as 1 ppm by germinating lettuce seed at 20 C on filter paper impregnated with brassin. At low concentrations a significant inhibition of radicle growth can be measured after 6 days. As brassin activity increases, root curling takes place. By substituting the filter paper with cotton and watering the germinated seeds with nutrient solution, the overall growth effect of brassins can be determined by measuring leaf area and taking fresh or dry weights.

Experiments to measure the effect of brassins on plant yields under field conditions - Beltsville, MD. To evaluate the effect of brassins on field-grown crop plants, potatoes were grown from seedpieces treated with $10\mu g$ brassins. This treatment significantly increased (5% level) the number and weight of marketable tubers produced. Soybean and snap bean seedlings treated with $3\mu g$ and $30\mu g$ of brassins in lanolin at the second internode gave an early significant response in height and stem thickening, but there was no effect on yield.

Effect of methionine on the growth of soybean cotyledons - Ithaca, NY. Soybean cotyledons were grown in vitro with and without added methionine. One series of 5 pairs of isolated cotyledons which were grown on an enriched methionine medium increased in dry weight by 32% and increased their methionine content of protein fraction by 24%. Tests with several other amino acids showed no effect on the growth or protein composition of these cotyledon tissues. One explanation for the methionine growth effect is that an inadequate rate of methionine biosynthesis limited protein synthesis and hence growth. This hypothesis has been tested by measuring the amino acylation of methionine t-RNA in cotyledons grown with and

without exogenous methionine. Sixty-two percent of the methionyl t-RNA of methionine-fed cotyledons were attached to methionine, whereas, in control cotyledons 52% of the methionyl t-RNA was aminoacylated. This 10% difference is less than one would expect for the observed growth difference but has been shown to be consistent.

Soybean cells in culture have been screened by exposing the cells to a toxic level of methionine antagonists, ethionine and trifluoromethionine. Approximately 200 lines of cells have been obtained that grow on toxic levels of methionine antagonists. Fifty-five of these mutant lines of cells have been compared with normal cells for concentration of uncombined methionine. Ten lines had an uncombined methionine content 15 to 30 times that of normal cells on a dry weight basis.

Technological Objective 7.

Develop technology for reducing damage to crop plants from air pollutants.

Research Location:

1109 Beltsville, Maryland

Selected Examples of Recent Progress:

Investigations to determine the dose-response and toxic mechanisms of air pollutants on plants - Beltsville, MD. Plant absorption and effects on photosynthesis of three major phytotoxic air pollutants resulting directly or indirectly from fossil fuel utilization (SO_2 , NO_2 , O_3) were investigated. All three pollutants were absorbed by bean leaves at maximal theoretical rates based on diffusion limiting calculation. Viable mesophyll interfaces, under the conditions of the studies, acted as ideal sinks absorbing the gases rapidly and quantitatively. Absorption rates were limited only by diffusion through the stomata. Catalytic systems at the mesophyll interfaces (possibly hydrogen-donating and oxidizing redox enzyme systems) appear to be active in the gas absorption process. Although pollutants in elevated concentrations, these three gases exist as natural background gases in the atmosphere subject to concentration-dependent evolutionary adaptations.

Net photosynthesis studies, conducted in specially designed and tested Physiological Activity Chamber, showed O_3 to be twice as inhibitory in suppressing CO_2 , and more than 5 times more inhibitory than NO_2 . Threshold concentrations required to suppress photosynthesis occurred near the ambient air quality standard for O_3 and below the secondary air quality standard for SO_2 . There is a large margin of safety for NO_2 , although NO_2 seldom occurs alone in polluted atmospheres. Experimental evidence exists which indicates that NO_2 can potentiate plant injury when in combination with SO_2 .

Physiological investigations with DPX4891, a growth regulator developed by DuPont which increases the tolerance of ozone sensitive plants of O₃, showed that photosynthesis and transpiration rates of plants treated either with soil or foliar applications were equal to or greater than unexposed control plants. This chemical may function by increasing the activity of protective enzyme systems. Leaves stressed for iron--a key cofactor of redox enzymes thought to be operative--lead to symptoms of injury similar to that caused by oxidant stress.

Estimated possible impact of air pollution on alfalfa production through the use of open-top field chambers - Beltsville, MD. Alfalfa, cv. WL311, a recommended cultivar for Maryland growers, was seeded on April 13, 1976. Plots were identified and three treatments replicated three times were imposed on July 15: 1) chambers with carbon-filtered air, 2) plots with nonfiltered air, and 3) nonchambered plots typical of commercially grown alfalfa but exposed to the same air quality as plants in the nonfiltered air chambers. Two harvests were taken in 1976 and 5 harvests were taken in 1977. Liming and fertility needs were determined by the Maryland State Soils Testing Laboratory, and their recommendations were followed both years. Soil moisture was supplemented by timely irrigations. Ozone injury on foliage was very minor during both years. There was no difference in the level of foliar injury on plants growing in either nonfiltered air chambers or in nonchambered plots.

Forage yields (mean per each of seven harvests) are reported as metric tons per hectare: 1) filtered air 2.63, 2) nonfiltered air 2.65, and 3) nonchambered plots 3.19. Yields from filtered and nonfiltered air chambers were non-statistically, significantly different but both had significantly lower yields than those from non-chambered plots. There was no significant difference in percent protein of the forage from the three treatments.

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National Research Program 20180

CROP POLLINATION AND HONEY PRODUCTION

This National Research Program involves research on projects designed to improve beekeeping management for honey production and crop pollination. Studies include colony management, control of diseases and pests of bees, honey bee breeding and genetics, bee poisoning by pesticides, wild bee biology, properties of apiary products and the use of bees in pollinating crops worth about \$8 billion. The objectives of the research include the development of improved methods that will benefit producers and consumers.

NPS Contact: E. C. Martin

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Technological Objective 1.

Improve management of honey bees for most effective crop pollination and honey production.

Research Locations:

5502 Tucson, Arizona
1110 Beltsville, Maryland
3507 Madison, Wisconsin

Selected Examples of Recent Progress:

Management studies - Madison, WI. Labor-time input studies of several honey bee management methods showed the two-queen system, as developed at the Madison Laboratory, superior to other systems of management for honey production.

Bee nutrition and pollen substitutes - Tucson, AZ, Beltsville, MD and Madison, WI. From a management standpoint bee nutrition studies focus on the development of suitable substitutes for natural pollen. Optimum protein and ash levels have been determined and standardized bioassay methods for preliminary comparison of diets have been developed. A clearer picture is being developed of honey bees' requirements for amino acids, lipids, vitamins, minerals and sugars. A synthetic pollen ash has been developed. Some of the volatile chemicals in pollen attractive to bees have been identified. A study of comparative value of different plant sources of pollen was carried out in the Tucson area.

Technological Objective 2.

Improve methods of protecting bees from pesticides, diseases, pests, and pollution.

Research Locations:

5502 Tucson, Arizona
1110 Beltsville, Maryland
3507 Madison, Wisconsin
5610 Laramie, Wyoming

Selected Examples of Recent Progress:

Resistance of Bacillus larvae to oxytetracycline (Terramycin) - Beltsville, MD. There has been concern that Bacillus larvae, the causative organism of American foulbrood, may be developing resistance to this antibiotic. Fifty-five isolates of Bacillus larvae were made at random to determine whether resistance to oxytetracycline is present in nature. No sign of resistance was seen in any isolate.

Ecology of European Foulbrood - Beltsville, MD. European foulbrood is particularly serious among honey bee colonies used for the pollination of blueberries or cranberries. Test colonies fed patties containing oxytetracycline remained free of the disease, whereas check colonies contracted the disease. Also, package colonies located in a blueberry-cranberry area contracted European foulbrood, whereas check colonies located outside the blueberry-cranberry area did not contract the disease.

Spiroplasmosis and an F-virus in honey bees - Beltsville, MD. Spiroplasma were found in 36% of foraging bees from a group of eight colonies. The disease peaked early in May and the latest infection of the 1977 season was found on June 6. The spiroplasmosis has been identified from bees in New York State and Hawaii, in addition to Maryland. Identical spiroplasmas have been identified from the flowers of dandelions, tulip poplar and southern magnolia. Details of the relationship between the organisms found in flowers and honey bees have not been worked out. Further studies on an F-virus identified in 1976, indicate that this virus is responsible for a condition previously identified as being caused by rickettsia in Europe.

Effect of biological insecticides on bees - Beltsville, MD. Three groups of microbial insecticides, polyhedrosis virus-Autographa californica, Heliothis virescens; fungus-Hirsutella thompsonii; bacteria-Bacillus moritai, Bacillus sphaericus were fed to individual bees and to bees in nuclei. No deleterious effects or abnormal mortality was observed in the caged bees or bees in the nuclei.

Control of chalkbrood of honey bees - Tucson, AZ, Madison, WI, Laramie, WY. Chalkbrood, a fungus disease of honey bees has been causing considerable loss in recent years. Tests indicated that spring feeding of pollen supplements to stimulate brood rearing and population build-up helped keep the disease under control and maintain the strength of the colony. There has been concern that oxytetracycline might enhance the development of chalkbrood in honey bees. No indication that oxytetracycline inhibited or enhanced chalkbrood was observed in tests during 1977. Use of 10,000 ppm. ascorbic acid in pollen cakes fed to honey bees was partly effective in reducing the incidence of chalkbrood in test colonies. Tests indicated some variation in susceptibility of different strains of honey bees to chalkbrood infection. Colonies became infected when fed pollen patties containing chalkbrood indicating that chalkbrood almost certainly was introduced to this continent in pollen purchased from European beekeepers.

Synergistic effect of herbicides on insecticide toxicity to honey bees - Laramie, WY. No synergistic effect was identified on monocrotophos, carbaryl, carbofuran, diazinon, malathion, methylparathion, parathion and mevinphos by the herbicides atrazine, simazine, monuron, and 2-4-D.

Protecting honey bee colonies from toxic sprays in cotton - Tucson, AZ and Laramie, WY. As an alternative to moving colonies away from pesticide dangers, various methods of protecting colonies have been tried. In 1977, the feasibility of maintaining colonies under shaded ramadas was tested in Arizona. Colonies were successfully confined under ramadas for 48 hours. Saran lumite screen or plain burlap served best to confine the bees. Colonies supplied with water internally within the hive survived in much better condition than those which did not receive water. Four promising methods of protecting bees were tried singly and in combination on 160 colonies. Best protection was obtained by covering the colonies with burlap, feeding pollen, shade, and supplying water within the hive. With combined treatments, more than 80% of the colonies survived while only 15% of the check colonies survived.

Micro-encapsulated methyl parathion in pollen - Tucson, AZ and Laramie, WY. Penncap-M was found to be picked up readily when bees collected pollen, thus verifying the fact that this pesticide can be collected and stored by bees in their pollen supply. Pollen in combs contaminated with Penncap-M was found to be toxic to bees more than 14 months after it was first contaminated. Laboratory analysis of the 14 month pollen samples indicated the presence of 28 ppm. for methyl parathion and also indicated the presence of products of polymer (capsule) degradation.

Technological Objective 3.

Determine pollination requirements of economically important crops.

Research Locations:

5502 Tucson, Arizona
5702 Logan, Utah
3507 Madison, Wisconsin

Selected Examples of Recent Progress:

Pollinating crops with non-Apis bees - Logan, UT. Osmia lignaria proved to be very efficient in the pollination of almonds at two California locations. Methods of maintaining populations of these bees have been satisfactorily worked out. Fifteen species of wild bees were identified working oilseed sunflowers. Some visitors had 100% sunflower pollen on their bodies. One Sayapis will utilize domiciles and nested and reproduced well in cages. An established Eurasian bee, Osmia coerulescens, was a promising pollinator of several kinds of clovers and nested well in artificially provided domiciles.

Floral characteristics of inbred lines of carrots - Madison, WI. Differences in floral characteristics of inbred lines of carrots for hybrid carrot seed production are being identified. Seed yields and the extent of floral differences between parental lines are inversely correlated. There is also evidence of some physiological incompatibility between lines being used for hybrid seed production.

Honey bee contribution to soybean pollination - Madison, WI. Evidence is accumulating that soybean yields of some varieties do, in fact, respond to pollination by honey bees, both in cages and open field tests. Outcrossing among soybean varieties caged with honey bees remained between 0.1 and 5%.

Details of soybean floral anatomy were studied with the use of the scanning microscope. The structure of the flower and particularly the nectary, suggests that soybean flowers were originally entomophilous.

Cranberry pollination by honey bees - Madison, WI. Yield of cranberries in Wisconsin has varied from 500 barrels per acre without bees to 2,400 barrels per acre with two colonies of honey bees per acre.

Watermelons pollinated - Tucson, AZ. Honey bees pollinated watermelons in polyethylene greenhouses. Where honey bees were present, 41 to 95% of the blossoms set fruit. Flowers excluded from bees set no fruit.

Honey bees used to produce a commercially adequate yield of hybrid cotton seed - Tucson, AZ in cooperation with the Arizona State Agricultural Experiment Station. Loss of yield due to too early cessation of flowering by the pollinator plants was documented. Also, effect of insecticide spraying on bee visits and resulting drop in set of male sterile flowers were recorded. The losses in yield from both the spraying of insecticides and the early cessation of flowering can be reduced by proper management.

Aroma burst in alfalfa flowers - Tucson, AZ. At a certain stage in the development of the alfalfa flower an "aroma burst" or an increase in aroma emanation occurs. This is at approximately three times the previous emanation levels. This rapid change in alfalfa flower volatile release may presignal the optimum time for pollination and be associated with a greater attractiveness to bees.

Technological Objective 4.

Identify and study biology of wild bee pollinators and improve methods of using wild bees for crop pollination.

Research Location:

5702 Logan, Utah

Selected Examples of Recent Progress:

Expanding identification and biological knowledge of native bees - Logan, UT. We have knowledge of less than 10% of our native bees, many of which may be important in the pollination of important wild and cultivated plants. Studies of the taxonomy and biology of native pollinators included: (1) A study of stem-inhabiting native bees at study sites near Logan, Utah; (2) An unidentified native bee that collected pollen from common desert plants; (3) Observations of several thousand nests obtained from trap nests placed in Arizona and New Mexico with new host-parasite records and pollen plants visited. (4) Floral preference studies for a group of native Arogochila sp.; (5) A population dynamics study of Halictus farinosus, a semi-social native bee. (6) Biological studies of native species in the greenhouse including Osmia coloradensis, O. californica, O. montana, O. lignaria, Stelis montana, and Hylaeus sp. (7) Nests of 15 species of native leafcutter bees in the genus Proteriadus were found and studied.

Ecology of *Megachile pacifica* - Logan, UT. The alfalfa leafcutter bee *Megachile pacifica*, one of the most important pollinators of alfalfa,

is being severely affected by chalkbrood. Studies of a strain from Spain were carried out and this was hybridized with the U.S. strain.

Foreign pollinator studies - Logan, UT and PL 480 Cooperators. Progress was made in Poland in the domestication of four Megachile species which are potential alfalfa pollinators. Greenhouse studies continued on seven foreign strains of candidate pollinators.

Technological Objective 5.

Improve honey bee breeding and rearing.

Research Location:

7413 Baton Rouge, Louisiana and Extramural

Selected Examples of Recent Progress:

A general research format for bee breeding - Baton Rouge, LA. Includes laboratory testing, selection index development, and breeding for specific combining ability. As a contribution to selection index theory, parent-offspring regression, intra-sire regression of offspring on dam, and sibling analyses were examined for their usefulness in estimating heritabilities of characters of the honey bee.

A study of resistance of honey bees to Nosema apis - Baton Rouge, LA. In determining strategies for measurement of response to Nosema infection, it was determined that adequate protein diet increased the average longevity of caged bees from 14 to 21 days and the presence of comb in the cages resulted in a 12-day increase in longevity of infected bees. Non-infected bees in cages hoarded a significantly greater amount of syrup per day.

Empty honey comb was discovered to be a primary behavioral stimulus for nectar-foraging of honey bees - Baton Rouge, LA. Laboratory and field experiments showed that nectar gathering and honey production increased as the amount of empty comb available to bees increased. Application of this principle to the management of honey bee colonies could result in greater honey production per colony.

Efforts continued to store honey bee sperm in liquid nitrogen - Baton Rouge, LA. The most successful mixture for storage was 60% semen, 10% dimethyl sulfoxide (DMSO), and 30% saline. Some progeny was obtained from honey bee semen stored in liquid nitrogen.

Alarm pheromones of honey bees - Baton Rouge, LA and the Georgia State Agricultural Experiment Station. Volatile compounds present in the sting apparatus of worker honey bees were analyzed by gas chromatography-mass spectrometry. Eight acetates, including N-butyl, isoamyl, N-hexyl, N-octyl, N-decyl, and benzyl acetate were detected. These esters were accompanied by isoamyl alcohol, 2-nonanol and benzyl alcohol, as well as a series of aliphatic hydrocarbons. Of ten chemical components of alarm pheromone evaluated in laboratory tests of defensive behavior, only one, benzyl alcohol failed to consistently stimulate workers to respond. Significant colony differences were found in response to four of the chemicals.

Africanized honey bees - Baton Rouge, LA and the University of Kansas.
Studies of feral populations of Africanized honey bees in South America continued. During 1977 studies were concentrated in French Guiana. The Africanized bees have now reached Venezuela. Swarming is extreme and in nature one unmanaged colony can serve to generate more than 34 progeny colonies in one year. Feral colonies will swarm 60 to 70 days after hiving. Swarming occurs most frequently between August and February which coincides with a period of reduced rainfall. Absconding occurs primarily from May to June during the rainy period. Preferred cavity size for swarms was identified as approximately 22 liters.

Technological Objective 6.

Develop methods of detecting honey adulteration; improve processing practices; increase industrial uses and identify biological characteristics and components. Study food potential of bee-gathered pollen. This T.O. is assigned to NRP 20520, but is briefly included here to present all apicultural research in one document).

Research Location:

1402 Philadelphia, Pennsylvania

Selected Examples of Recent Progress:

Tests developed to distinguish corn products from honey - Philadelphia, PA.
An absolute test for the addition to honey of corn syrups has been developed and qualified. The fundamentally different photosynthetic pathways between the corn plant and nectar-bearing plants result in differing ratios of the 13 and 12 isotopes of carbon in their constituents. The very narrow limits of variability in the syrups facilitate the identification of fraudulent addition of corn products to honey. This will permit effective enforcement of laws protecting the purity of honey and in maintaining consumer confidence in the honey market.

Two additional test procedures have been developed. One procedure uses thin layer chromatography and has the potential to detect corn syrup at lower levels than the isotope ratio test. The other test uses gas liquid chromatography and will provide a reasonably effective screening method. Both procedures use commonly available, relatively inexpensive laboratory equipment and can be carried out in field laboratories. After the required collaborative testing, these methods will be available for use by regulatory agencies.

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National Research Program 20190

IMPROVED METHODS AND EQUIPMENT FOR PRODUCTION OF FIELD, HORTICULTURAL AND FIBER CROPS

This Program involves development and improvement of equipment and techniques to solve urgent problems in the production of a wide variety of field & horticultural crops. The problems addressed are associated with harvesting, farm processing after harvest, planting and other cultural operations, and the improvement of environmental facilities, such as greenhouses and growth chambers. Reductions of losses, of fossil fuel use and of costs for labor and machinery are emphasized. The research is primarily of an engineering nature, but involves extensive cooperation with crop scientists, soil scientists, horticulturists and representatives of the equipment industry.

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Research Locations:

5205	Salinas, California	1109	Beltsville, Maryland
5203	Shafter, California	3508	East Lansing, Michigan
7614	Belle Glade, Florida	7502	Mississippi State, MS
7609	Lake Alfred, Florida	7402	Stoneville, Mississippi
7706	Byron, Georgia	5809	Corvallis, Oregon
7702	Tifton, Georgia	7313	Lubbock, Texas
5220	Honolulu, Hawaii	7307	Temple, Texas
3311	Urbana, Illinois	7812	Suffolk, Virginia
7809	Lexington, Kentucky	5803	Wenatchee, Washington

Note: Elements of NRP 20190 concerning solar drying of crops other than grain and the applications of power from wind are reported separately under SRP-5 by the FR Coordinator for Energy.

Technological Objective 1

Develop improved equipment for harvesting crops to reduce field losses, improve product quality, reduce labor and machinery costs, and reduce fossil fuel use.

Selected Examples of Recent Progress:

Tying machine developed for cauliflower - Salinas, CA. Cauliflower should be shaded as it matures to prevent strong taste and discoloration. This is usually done by hand by binding the leaves over the developing head with a rubberband.

A tyer was developed which individually ties approximately 93% of the plants. Less than 1% are not tied. The remainder are 2 plants tied together with 1 loop of twine or plants tied with 2 loops of twine. A two-row machine can tie approximately 0.5 acre per hour at a cost of \$15 per acre for string and \$30 per acre for labor and machine costs.

Principle for removing chili peppers proved feasible - Salinas, CA. Several different fingered belts and methods of pulling the plants through the belts were tested for removing peppers. Very stiff plastic fingers, 2-3/4 inch long spaced 1-3/4 inches x 2 inches, removed the peppers effectively. These fingered belts also conveyed the peppers after removal. The belts do not pull up the plants if the ground is firm but will pull up some plants if the ground is very wet. The harvester was sufficiently developed late in the season to allow evaluation of the material collected. Most of the peppers (93.5%) were removed with only peduncles attached as desired, 5.5% were removed with the peduncles pulled out and 1.1% had a piece of a branch attached.

Mechanical sugarcane harvester performs satisfactorily on selected varieties - Belle Glade, FL. A three-year study of harvester performance using selected cane varieties showed that a gathering-type mechanical sugarcane harvester is capable of recovering 95 to 98% of the crop. The harvester uproots stalks in the ratoon crops when the stalks are recumbent or are partially uprooted by windstorms. Trash contents increase drastically when plant populations decline and the harvester cannot clean the green trash from the stalks.

Self-propelled combination rake-pickup machine developed for citrus harvesting - Lake Alfred, FL. Fruit windrowing, pickup, cleaning, and loading concepts and components developed and proven in previous research were combined into a single, one-operator machine for the purpose of reducing machine costs, power requirements, and labor required for citrus harvest as compared to single-function machines. A power unit previously used to operate a 13-brush, single side, windrow machine proved more than adequate. The "drip-line" pickup concept was used with two nylon brushes providing the windrowing function. An oblique-type rake on the front of the machine cleared the drive middle and moved the fruit in line with the pickup head. An inclined-belt trash separator rotating in the same direction as the pickup chain was quite effective in removing most trash, as well as any crushed fruit. A vertical, bucket-type, elevator raised the fruit to the top of the machine for direct loading into a grove truck pulled by the combination machine. Preliminary field tests in Hamlin oranges, Dec. 1977, showed that the components were well matched and fruit was loaded at a groundspeed of 0.9 km/hr. The trash eliminator was the limiting factor in the rate of fruit pickup.

Fruit quality of mechanically harvested oranges studied - Lake Alfred, FL. In the second year of a five-year program samples were taken in the harvest operation to compare the commercial rake and pickup and the offset rake and pickup systems for fruit handling ability. Because of the freeze only three tests were conducted in the early and midseason varieties. Fruit was checked for decay after being stored for seven days at 21°C and 85% R.H. Results indicate that less mechanical damage occurred with the offset system. This system requires less movement of the fruit before being picked up.

Field counts of fruit damage were made on the day of harvest at three points in the harvesting operations to determine cumulative fruit damage in the system. Percent unwholesome fruit on the ground averaged .77%, in the windrow 1.1% and in the highlift truck 1.4%.

Continuously moving shake-catch mechanical harvester for tree crops developed - Byron, GA. This harvester moves along a row of trees and harvests the crop without requiring a stop at each tree. Harvest rates are about double those possible with conventional stop-and-go harvesters, and operator fatigue is greatly reduced. These advantages are especially important in orchards with high-density plantings. The increased harvest rates from a continuous harvester can greatly improve the economics of mechanically harvesting crops like peaches, for which the numbers and capability of the hand-harvest labor force is decreasing each year.

Harvest of Chinese chestnuts mechanized - Byron, GA. Hand harvesting Chinese chestnuts is very difficult and inefficient. A system and equipment have been developed to once-over shake-catch harvest the nuts and subsequently debur them. Early storage information for improved color appearance has been obtained. Although most seedlings are not suited for a once-over harvest, a few have excellent uniformity of nut maturity as well as good quality. Orchards propagated from these superior seedlings could be mechanically harvested efficiently. Chestnut is a minor crop in the U.S., but has good potential because of high demand and price.

Pecan harvester for small orchards further developed - Byron, GA. A small, low-cost ground-pickup pecan harvester, powered by a small garden tractor, was further improved. The machine is suitable for plantings up to about 20 acres and harvests up to 1/3 acre per hour. Nut recovery exceeds 90%, which is better than most hand harvesting. Trash content is less than 50% and comparable to commercial-size machines.

Tandem Roll Mower-Conditioner (TRMC) Increases Drying Rate and Digestibility of Coastal Bermudagrass - Tifton, GA. A set of smooth steel crushing rolls was mounted behind the standard rolls on a mower-conditioner. When used in Coastal bermudagrass, the TRMC resulted in a significantly higher drying rate of the forage. The in vitro dry matter digestibility of forage treated by the TRMC had 28.1 and 16.9 percent more dry matter disappearance in 24 hours than the conventional sickle bar mower and the standard mower conditioner, respectively. In 48 hours, in vitro digestibility was 14.8 and 11.6 percent greater from the TRMC than for the sickle bar mower and mower conditioner, respectively.

Research findings stimulate improvements to soybean headers - Urbana, IL. Research on soybean harvesting loss reduction has encouraged the farm equipment industry to provide several new soybean headers that reduce harvesting loss to less than 3 percent of yield.

Field tests were made to compare the research-developed air-jet header to a commercial built-in flexible cutterbar equipped with air jets and to a commercial row-crop header for soybean harvesting. Comparisons

were made in four varieties of soybeans planted in 18-cm and 76-cm rows. In the 18-cm rows, the commercial flexible cutterbar was the most efficient and its efficiency was not improved by the addition of the air-jet system. The commercial row-crop header was the most efficient header tested in 76-cm row soybeans. Laboratory test stand results indicate that other commercially available headers will also provide harvest loss reductions equivalent to the air-jet header.

Progress made on mechanical harvesting of burley tobacco - Lexington, KY. An experimental self-propelled, self-steered burley tobacco harvester has been constructed that is capable of being operated by one person. The harvester automatically cuts the plants and conveys them to an operator who manually spears the plants onto a mechanical spearing aid. The harvested tobacco is placed on conventional tobacco sticks, allowing the crop to be handled and housed for curing in unmodified tobacco curing barns. A manufacturer has constructed stamping dies to fabricate roller chain having attachments complying with specifications obtained from the research. This chain will be a commercially available item useful for stalk-cut tobacco harvesters. Field tests indicate a labor requirement for the harvester to be about 12 man-hours per acre, a 40 percent reduction compared to conventional manual harvesting. The harvester can be fabricated and assembled in local machine shops.

Mechanical harvesting of rhubarb gaining acceptance - East Lansing, MI. Several rhubarb harvesters have been built based upon the SEA design. Harvesting of "Valentine" was evaluated for the Michigan spring & summer crops, indicating recovery of 60% to 70%. Although further improvements are necessary, mechanical harvesting is being accepted by both growers & processors.

Progress in harvester development for peppers continues - East Lansing, MI. Nine harvesting principles were tested on 16 different variety types of peppers. Recovery of peppers was 90% or higher with damage less than 10%. The open-helix principle proved superior in the tests. Five experimental mechanical harvesters are being built to be used in further tests on five varieties in four states.

Development of over-the-row multi-purpose power frame progressing - East Lansing, MI. An over-the-row power frame was modified for the purpose of testing a new continuous sway-bar shaker. Field tests in a commercial orchard on 9-ft tall central-leader, spur-type Red Delicious trees removed approximately 100% of the fruit at a shake frequency of 190 cpm and ground speed of 1 mph. Maneuverability was satisfactory. Limb and bark damage was not significant. About 75% of the fruit were free of injury.

To provide spraying capability with the same frame, a small compact pesticide metering and mixing system was constructed and preliminary equipment performance tests were conducted in the SEA lab. at Wooster, OH. The results were used as the design basis for a field-test unit being built for the over-the-row power frame.

Feasibility of harvesting unopened cotton bolls studied as a method for reducing dust problems - Mississippi State, MS. & Lubbock, TX.

Two bales of green bolls were harvested without bracts by hand and allowed to open in a dust-free environment. The seed cotton from one bale was separated from the carpels by hand and ginned in a clean gin. The seed cotton from the other bale was mechanically removed from the burrs. Other cotton bales were machine harvested and ginned normally. Dust levels from these cottons will be measured and also evaluated with human byssinosis reactors in the mill card room. White-cotton blooms were tagged and green bolls were harvested when they were 31, 38, 45, 52 and 59 days of age. Tests were performed on the fibers from these green bolls by the SRRC which indicated that the never-dried fibers do exhibit the high elongation properties ascribed to them in the literature. Chemical fixation works only for a short period of time. (MS)

Unopened cotton bolls were harvested by machine stripper and the bracts were removed by hand. Bolls were dried and allowed to open without contamination from leaves or outside dust. A bale was ginned and shipped to Clemson Laboratory for spinning studies and dust measurements.

Equipment for processing single boll samples for dust was built and evaluated. Dust sizing data have been collected and a computer program is being developed to analyze these data. (TX)

Effectiveness of cotton-harvesting principles compared - Stoneville, MS.

The harvesting efficiency & the potential for harvesting cost reduction of brush-roll strippers and finger strippers were compared with conventional spindle pickers. Three fields, selected for different soil types, were planted with Stoneville 213 cotton on 1.02 meter rows. In one field the plant population was varied at three levels, with a range of approximately 8,097 to 28,340 plants per hectare to evaluate effect of plant population on stripper efficiency. Harvesting treatments were: (1) picking at 70% open cotton; followed by harvesting with the three harvesters at 100% open cotton, (2) harvesting once-over with all three harvesters at 100% open cotton. Tall and rank cotton plants were generally grown in all three fields. This type plant inhibited both stripper harvesters in removing the cotton from the plant. The finger stripper experienced more harvesting difficulties than the brush-roll stripper because the fingers of the stripper would become clogged with stalks. This clogging caused excessive down time (approximately 50%) for the finger stripper and ground speed had to be reduced to 3.5 km/hr. The brush-roll stripper harvested at 4.3 km/hr and had very little down time (approximately 10%). The spindle picker had a ground speed of 5.0 km/hr and no measurable down time. At present, ginning result has not been completed but it appears that trash content from both strippers was exceptionally high and will result in grade reductions. Also, yield will be lower from the stripper harvesters with the lowest yield from the finger stripper.

Development of components for combine to harvest forage crop seed continued - Corvallis, OR. Experimental units for threshing and for seed separation were evaluated for incorporation in a field combine. An experimental pneumatic separator was constructed to determine the effects of various design features on separating efficiency. Tests were conducted with existing pneumatic units to investigate their capabilities in separating several mixtures, including bluegrass with water foxtail, orchardgrass with ryegrass, and onion with trash. The laboratory-size belt thresher was tested with several seed types, including carrot, sugarbeet and zinnia, to provide an indication of its effectiveness in threshing in the field and in removing undesirable surface material from seeds. Subsequent separations of these seeds were improved by the threshing action.

"Direct harvester" for peanuts shows promise for the "green" peanut market - Suffolk, VA. An experimental "direct harvester" was operated throughout the season to harvest breeder seed and high moisture peanuts for drying studies. Stemming saws of a slightly different diameter and tooth design were installed in the destemming section. By observation these changes did not adversely affect destemming efficiency. Cooperative work with a South Carolina peanut producer indicated that the direct harvester has a definite potential in the green boiled peanut market (no drying required). A product can be put on the market with little additional preparation before taking the peanuts to the processor. The quality of the product as indicated by bruised and damaged pods is superior to green harvesting with conventional combines.

Equipment for harvesting apples, pears & peaches improved - Wenatchee, WA. Operation of the low-profile catching frame fruit harvester was improved with an automatic trunk sensing device. The electromechanical system automatically stops the shaker half of the harvester for proper clamp attachment to the tree trunk. Harvesting efficiency was increased by eliminating the previous frame repositioning time. The 1977 apple harvesting rate was 1 min/tree compared with 1.4 min/tree in 1976. Red Delicious cullage was 20% in 1977 compared with 14% in 1976. Insufficient fruit prevented a commercial packout with hand picking comparison. During the 1977 field tests, two catching frame deceleration surfaces were compared with the 1976 surface. No improvement was noted. After harvest, drop tests onto a combination surface showed the most potential for reduced fruit bruising. Five fruit distribution pans were tested for the low-profile harvester bin filler. The least cullage and best distribution at all flow rates tested was obtained with a two-way, two-exit pan rotating at 14 rpm. Maximum filling rate averaged 2.88 kg/sec (381 lb/min) with a Golden Delicious cullage of one percent.

Mechanically harvested Bartlett pears averaged 39.3% culls and 77.2% removal at a 18.3 lb pressure test. Five days later, at a 17.5 lb pressure test, cullage averaged 41.5% with a 93.1% removal. A hand picker produced 23.3% culls on the later date. Mechanical thinning of peaches with a hand thinning follow-up provided a two season average time saving of 61.6% when compared with conventional hand thinning. The least yield reduction due to over-thinning was 31.2%.

Technological Objective 2

Develop improved equipment and techniques for farm handling, cleaning, drying and processing of harvested crops to improve quality, reduce costs of labor and machinery, and reduce fossil fuel use.

Selected Examples of Recent Progress:

Packing procedures for mechanically harvested lettuce compared - Salinas, CA. Mechanically harvested lettuce was transported to a central location and packed in cartons with no more damage than when packed on the harvester. However, soiling of the lettuce butts necessitated retrimming of all the heads to achieve similar appearance to hand harvested lettuce. This requirement off-set the expected advantages of centralized operations.

Systems which have been tested for handling mechanically harvested lettuce are: 1) Packing the lettuce into cartons on the harvester, 2) packing the lettuce into cartons at the side of the field, and 3) tumbling the lettuce into shipping bins on a trailer pulled alongside the harvester. Alternatives 1 and 3 are preferable to 2, as described. Method 3 is the most efficient and compatible with mechanical harvesting; however, the industry has shown little interest in shipping lettuce in bins. All of these systems greatly reduce or eliminate the amount of stoop labor required.

Appearance of Chinese chestnuts improved by holding at ambient temperature Byron, GA. Mechanically harvested Chinese chestnuts of non-uniform maturity were stored in-the-bur for 4 to 5 days in August at ambient temperature. All nuts stored this way improved in color and appearance. A slight number developed a mold inside the bur. This may have been because of the high temperature and moisture conditions in the bur. Multiple harvests of trees did not improve overall nut appearance.

Energy requirements for processing forage crops compared with their nutritive value - Tifton, GA. Arrowleaf clover and soybeans were preserved as wilted silage by cutting and conditioning the crop, allowing it to wilt to 65% moisture, and then picking it up with a forage harvester. Careful records of diesel fuel use for the field operations were kept, as well as the amounts of preservative used. These energy inputs will be compared with the feed value of the forage, now being determined in feeding trials. Data of this type were previously accumulated on Tifton 44 Bermudagrass prior to its release, so it is now possible for the prospective user to evaluate the net energy value of the new grass before selecting it for planting.

Rumensin treatment increases gains from forage grasses - Tifton, GA. Progress: Rumensin (monensin sodium) was added to Coastal bermudagrass and Tifton 44 bermudagrass at the rate of 0.36 kg/tonne as the forage entered the pellet mill. Steers fed the pelleted bermudagrass containing Rumensin had 20 percent greater average daily gain and consumed 21 percent less feed per unit of gain than those steers receiving the same feed without Rumensin.

Procedures developed to conserve energy in drying peanuts - Tifton, GA. Tests were run to evaluate the potential for energy saving by interrupting the drying of peanuts. Peanuts with initial moisture contents of 16 to 30 percent were used. These tests indicate that with peanuts below about 20 percent moisture, the air flow may be interrupted for 45 minutes per hour, i.e., the drier only operated for 15 minutes per hour, without changing the rate of drying. At the 30 percent initial moisture, drying was interrupted for 30 minutes per hour without significant change in drying rate. When interrupted for 45 minutes per hour, the drying rate was significantly changed at the higher moisture content. These results are apparently due to the slowness with which the moisture moves from the kernel to the pod and the ease with which it may be removed from the pod.

Relationships of peanut kernel maturity, split kernels & curing methods investigated - Tifton, GA. Cooperative studies with the National Peanut Research Laboratory at Dawson showed that peanuts harvested at the optimum maturity for yield produced the greatest number of splits when shelled in commercial shellers. When peanuts were dried, with the same air flow rate, at 43.3°C, two to three times as many split kernels were produced in shelling than when the peanuts were dried at 35°C.

Factors to improve homogenized leaf curing (HLC) of tobacco analyzed - Lexington, KY A total of 130 cultural and processing experimental treatments were completed. Cultural experimental factors were plant variety, plant population, fertilization rate, plant maturity, leaf grade and type of harvest. Processing experimental factors were incubation duration, incubation temperature, and mechanical dewatering prior to thermal drying. A simplified crystallization procedure was developed for extracting protein Fraction I from mechanically dewatered effluent from unincubated or incubated HLC slurry. The data were evaluated by factorial analyses using eight constituents measured by routine chemical analyses to estimate variance. The data will be used in the design of new experiments to establish specifications for HLC processing.

Solar energy used for burley tobacco curing - Lexington, KY. The objective was to evaluate the capability of a chamber with solar collector and insulated rockbed heat storage and a chamber with solar collector and uninsulated rockbed heat storage to reduce high relative humidity during curing. The chamber with solar collector and insulated rockbed reduced relative humidity by as much as 17 percentage points, while the solar chamber with uninsulated rockbed reduced relative humidity by only 10 percentage points. The insulation is well justified and even more insulation is needed than was used in the insulated rockbed. It appears that, functionally, a solar collector-rockbed system can be effectively used to reduce high relative humidity during curing. However, a solar collector-rockbed system cannot economically compete with fossil fuel systems for curing stalk-cut burley at present prices.

Mathematical model used to analyze burley tobacco curing processes - Lexington, KY. A mathematical model is being developed to predict the temperature and humidity within tobacco barns during curing as a function of ambient temperature, humidity, wind speed and direction, and solar radiation. Preliminary comparisons show that the one-dimensional drying equation predicts the relative humidity of the air as it moves through the tobacco to within $\pm 6\%$ rh.

Progress made in mechanized handling of cured tobacco - Lexington, KY. Cured stalks of burley tobacco were sliced with the prototype slicer machine. Market weight losses were less than estimated by a prediction model. The slicer machine has an improved input conveyor and a horizontal discharge conveyor and pneumatic nozzles for conveying leaf material. Machine performance is independent of tobacco moisture content and stalk deformities. The flail-wiper mechanical tobacco stripper was improved by converting it to vertically-downward leaf discharge. A preliminary stalk chopper design was somewhat satisfactory. Data were collected on leaf removal and losses as functions of leaf and stalk moisture content.

Air purging of CO₂ from pickle processing tanks reduces costs - East Lansing, MI. A comparative cost analysis of air vs nitrogen purging systems for cucumber tanks was completed, showing that a cost savings of \$30 to \$60 per tank of cucumbers could result each year from using compressed air. An air supply system was designed, constructed by a pneumatic supplier, and evaluated by a cooperating processor in 1977. Processor and researcher evaluations showed the system to be properly designed and quality of the pickles to be excellent. More systems will be installed in 1978.

Bulk handling system for orchard handling & transporting of fruits shows promise - East Lansing, MI. To reduce costs, labor and handling damage a vacuum system was used to convey apples in water from a harvester into a transport tank, and then into and out of a silo storage. Apples for processing were handled rapidly in this manner without increased bruising. The equipment is being improved and may be useful for other fruits.

Improved separator for seed processing being developed - Corvallis, OR. A friction separator is being perfected to separate rough seeds from smooth ones by sensing frictional differences. The initial machines were used primarily to separate dirt clods from beans, and dodder from alfalfa. During the past year, significant advances were made in attaining commercial capacities by use of wide belts, and the machine was tested with additional seed mixtures showing good selectivity in 13 of them, including wheat with wild oats and dirt clods, radish with sclerotia, carrot with lamb's-quarters, and several tree seeds with pitch and trash. This machine will provide a new basic tool for the seed processing industry.

Studies of relations of drying conditions to peanut palatability continued Suffolk, VA. An initial attempt was made to relate peanut critical laboratory evaluation roast (CLER) scores to time of exposure at different temperatures and moisture contents during the drying process. A simplified peanut drying model was used to compute a quantitative index

for this exposure based on entering air conditions, airflow rate and initial moisture content. Based on the 1976 data, 32% of the variation in CLER scores of peanuts dried under various conditions can be explained by this index. Further development of the procedures for computing this index and its correlation with CLER score, germination and ethanol content is in progress.

CLER score, germination and gas chromatograph analyses on six lots of peanuts direct harvested (1977) and dried under controlled conditions are in progress. Peanuts harvested in 1976 and dried in the experimental semi-continuous flow drier using five different entering air conditions were CLER scored at 42-50. Samples (checks) of the same lots dried slowly were CLER scored at 48-54. Average germination of the treated and check samples was equal, 84%.

Equipment for measuring interior quality of apples improved - Wenatchee, WA. The special Neotec electronic fruit sorter was repaired and evaluated for sorting Golden and Red Delicious apples for color, water core and interior quality. Two design problems were discovered and analyzed: (1) For color sorting and interior quality determinations, the equipment did not respond quickly to low light levels, resulting in erratic grading. (2) It was discovered that detection of water core is affected by fruit size and density and that the optical-density difference measurement, ΔOD (760 nm - 810 nm), was not as effective as the single wavelength of 860 nm.

Technological Objective 3

Develop improved equipment and techniques for tilling, planting, transplanting, fertilizing, and cultivating to increase production, reduce labor and machinery costs, reduce fossil fuel use, and improve harvesting efficiency.

Selected Examples of Recent Progress:

Synchronous planting system for cauliflower developed - Salinas, CA. A planter was developed for synchronous planting of two rows (30 cm apart) of seed on each bed. The planter alternately dropped a group of three seeds on one side and then a group of three seeds on the other side. The spacing was designed so that after thinning the groups to one plant the minimum distance from plant to plant was 36 cm and the maximum distance to the nearest plant was 41.7 cm. The conventional method used is one row to a bed and thinned to 30.5 cm from plant to plant. The two-row system resulted in 43,100 plants/Ha as compared to the conventional system of 32,500 plants/Ha and the spacing between plants in the two-row system was more uniform. The increased population and spacing uniformity for the double row resulted in increased production and uniformity of maturation.

Planting method developed to reduce damage to tomatoes from soil-incorporated herbicides - Salinas, CA. Two field experiments conducted cooperatively with the University of California Cooperative Extension Service showed that a small volume of activated carbon (10% by weight of plug mix and .10 lbs/gal for transplanting) placed directly around the tomato seed with a plug planter system, or around the transplant with a transplanting system, reduced the herbicide damage to the tomato plants. The results were a function of the herbicide used. The increase in stands and yields due to the carbon treatment were greater for Sencor (metribuzin) than either Vegiben (Chloramben) or Tillam (pebulate). The plug mix of 1/2 by volume of peat and vermiculite was found to be unsatisfactory because it did not maintain adequate moisture for germination.

Punch-planting shows promise - Salinas, CA. Laboratory tests showed that punch planting is feasible for light and heavy soils and for wide ranges of soil aggregate sizes, soil bulk densities and soil moisture tensions. A single-row punch planter was designed, and a prototype built and developed. Preliminary tests indicated, rate of emergence, total emergence and early growth were better with the punch planting system than with a conventional system.

New cotton planter design includes herbicide incorporation - Shafter, CA. A cotton planter has been designed with features to solve most of the problems experienced by farmers in attempting to apply herbicide at planting: 1) compact design which does not require sled mounting, 2) optimum soil covering, eliminating compaction associated with past designs, 3) controlled placement of herbicide with incorporation on either side of the seed and deeper than seed depth. The design may prove superior to existing designs even when herbicides are not used. Adoption of this planter could result in a 70% decrease in use of preplant herbicide, with reductions in cost and impact on soil environment.

Tractor guidance system shows promise - Shafter, CA. A driver-assisted tractor guidance system was field tested in 1977 for accuracy and potential application. Using high speed photography, the accuracy was determined to be related to speed and better than $\pm .50$ inch at speeds up to 6 mph. This result was verified by using shielded sprays with a non-selective herbicide for nutsedge control: no cotton damage was visible at speeds up to 6mph, with nutsedge control to within 1.25 inches of young cotton plants.

Improved equipment for planting sugarcane pieces developed - Belle Glade, FL. - Research accomplished since 1974 resulted in a vibrating planter chute being used on a commercial semi-planter. This chute delivers the cane from the planter metering device to the open furrow. Imperfections in metering are somewhat overcome by the movement of the sugarcane pieces down the chute, where they accumulate and fall onto the ground as the planter travels through the field.

Research on optimum seed length for good germination and yield of mechanically harvested sugarcane resulted in commercial construction of mechanical planters with provisions for metering 20-inch lengths instead of 12- to 15-inch lengths with previous planters.

Sicklebar tree pruner shows promise - Byron, GA. An oversize cutterbar mower was developed to combine the advantages of the safety, low noise and low cost of a standard grass cutterbar with the ability to cut two inch diameter limbs. It is mounted on a standard farm tractor. Typical cutterbar breakage problems developed at the pitman drive end, but have been overcome with reinforced construction. Circular-saw machines can cut two-inch and larger diameter wood, but are dangerous, noisy, and have caused fires from accumulations of sawdust.

Methods of sod land preparation for peanuts compared - Tifton, GA. Six methods of land preparation for peanuts were evaluated for yield, grade and disease susceptibility. These were: (1) chisel plus deep turn, (2) deep turn plus row-mounted chisel, (3) deep turn plus sub-soil in row, (4) deep turn plus chisel and bed, (5) chisel and bed, and (6) conventional deep turned. There were no significant differences in any of the production factors used to evaluate the methods. The yield ranged from 3691 to 3736 kg/ha, the grade from 72.0 to 73.9 SMK and the disease loci/30.5m from 0.1 to 1.1.

Soybean planter developed which improves soil incorporation of nematicides - Urbana, IL. A JD Max-Emerge planter was modified to band-apply and incorporate nematicide granules during planting. Herbicide boxes mounted on the front of the planter dropped the nematicide ahead of rolling cultivators. Depth gauge wheels and additional weight controlled the cultivator penetration to 13 cm and resulted in granule incorporation to 7 cm.

Conservation tillage planter effective for sugarbeets - Lexington, KY. A conservation-tillage planter, originally designed for direct seeding of tobacco, has given outstanding performance in three years of testing on sugar beets at Scottsbluff, Nebraska. The planter produced very high seedling emergence compared to less than 50% emergence for five other experimental and commercial planter combinations. Because sugar beets are very sensitive to planting methods, the USDA planter design could be a highly significant improvement over commercially available planters. (Anderson, Frank. Influence of seedbed preparation and planter type of sugar beet emergence and yield. Unpublished Annual Report, Nebraska Panhandle Experiment Station, Scottsbluff, 1977).

Planter for interseeding legumes in pasture sod proves effective - Beltsville, MD. Equipment for interseeding of legumes in sod produced forage which increased animal gains and pasture carrying capacity as compared to sod or legumes alone. Weed populations were reduced. Seeding costs were less than for legume seedbed preparation. This system is especially applicable to marginal and hill lands. Cooperative with University of Maryland.

Use of mulching equipment increases yields of vegetables - Beltsville, MD. Equipment developed to apply aluminum and film reflective mulches produced substantial yield increases as compared with conventional row culture. Increases were up to 50% for cabbage, 190% for lettuce, 80% for cucumbers, and 60% for squash. Cooperative with Vegetable Lab., and Florist and Nursery Crops Lab., Beltsville.

No-till culture of dry beans successful - Beltsville, MD. Use of a no-till culture system employing herbicides for weed control slightly increased yields of dry beans, as compared with conventional field tillage. A further yield increase was obtained by decreasing row spacing from 28 in. to 19 in. Cooperative with Michigan State University.

Effectiveness of deep tillage and of multi-cropping evaluated - Mississippi State, MS. A controlled-traffic, residual tillage test was continued for a second year. The yield from the normal-traffic 1 meter bed plots was significantly higher than that from the wide-bed controlled traffic plots. Annual subsoiling increased yield slightly. Soil in all treatments had a low penetrometer resistance which may not have been critical for root growth.

Two multi-cropping studies using the wide-bed controlled-traffic concept were installed in 1977. Cotton, soybeans, corn, wheat and clover were used in both a 3-year and a 2-year rotation system. Wheat planted in the wide-bed controlled-traffic system showed a significant increase in germination and initial growth rate over wheat planted flat. An acceptable tool was developed to incorporate overseeded wheat and clover in standing cotton and soybeans.

Development of various models continued - Mississippi State, MS. Validation data were gathered on a cotton crop. These data have not yet been run in the model, COTCROP.

The Pheromone Trap Simulation Model was improved to allow us to distinguish between attraction to males and traps and to allow for attraction with or without capture. We feel that the program provides a realistic simulation of the actual behavior of the weevils. The next step is to use a model to develop estimates of the parameters for the eradication study as a function of trap and weevil densities.

An open circuit windtunnel, a two-dimensional rectangular target, and a uniform droplet generator were used to obtain experimental data for comparison with an existing simulation model. Four wind velocities and a range of droplet sizes from 113 to 338 μm were used in the experimental portion of the study.

The two-dimensional simulation model showed good agreement with experimental data for velocities below 0.65 meter/sec.

The equations of motion for an evaporating spray droplet approaching a three-dimensional target are developed based on the physical properties of the liquid and the air. These equations are programmed for solution with a digital computer. Selected cases from an experimental wind tunnel study are used as an input to the three-dimensional model and with experimental data. The three-dimensional program determines the five limiting trajectories necessary to predict the deposition efficiency on two faces of a three-dimensional rectangular object.

Wide-bed system for cotton production proved practical - Stoneville, MS. Equipment and management techniques have been developed and integrated to the point that the wide-bed cotton production system is practical for farmer application. The basic wide-bed system consists of two rows, one meter apart, on a 2.5 meter bed. Equipment has been designed to allow the basic production unit to consist of 6 rows (3 wide beds). Conventional tillage or limited tillage practices can be used in the system. Several adaptations of the wide-bed system (usually referred to as narrow-skip) are being used by the farmers in the Delta. Approximately 70,000 hectares of cotton were grown in 1977 using these adaptations.

Soybean planter designs compared for operation on clay soil - Stoneville, MS. Five soybean planters equipped with double-disk openers were evaluated on Sharkey clay soil. The planters evaluated were: John Deere 7100, John Deere 71, IHC 185, Case K160 and Burch. Depth adjustments were set on all planters to allow the openers to cut a drill furrow approximately 5.1 cm deep. Measurements taken of the actual seed planting depth indicated the following planting depths: Case, 5.5 cm; John Deere 71, 4.8 cm; John Deere 7100, 4.7 cm; Burch, 4.3 cm; and IHC 185, 4.2 cm. Final emergence data based on a percentage of seeds planted were as follows: John Deere 7100 and John Deere 71, 80%; IHC 185, 65%; Case 65% and Burch, 55%. These data indicate that planter design can have a significant influence on soybean emergence from clay soils.

Cotton lint yield increased by limiting boll development to two bolls per plant - Lubbock, TX. Under West Texas conditions, removing excess squares to limit boll development to two bolls per plant gave increased lint yields of 4% and 12%, respectively for Paymaster 303 and Paymaster 909. Lint micronaire value was significantly higher for controlled fruiting plants of Paymaster 303 than for check Paymaster 303 plants.

Damming furrows to reduce runoff increases cotton yields - Lubbock, TX. Damming equipment has been developed that will operate at 5-7 mph and vary dam spacing from 2 to 20 feet to impound runoff. Lint yields have averaged 41 lbs/acre higher for diked or dammed plots than for undammed furrows. No runoff has occurred on slopes of up to 1.2 percent.

Methods of crust-breaking compared to aid cotton emergence - Lubbock, TX. Effects of breaking soil crusts over seeded cotton rows by retracing the rows with coulter discs were compared with rotary hoeing. A larger number of cotton seedlings emerged after breaking the crusts with rotary hoes than with coulter disks. As depth of operation or time from planting increased the benefits to seedling emergence decreased.

Automatic system for transplanting range grass seedlings being developed - Temple, TX. Propagating Kleingrass seedlings and transplanting them appears to be a more promising method for range establishment than seeding. Elements for an automatic transplanting system are being developed. Seedlings for automatic transplanting are probably best raised in cells about 8mm in diameter, 6 cm long, and connected together in a bandoleer. Bandoleers can be placed in modules in which seedlings are grown under

controlled conditions and transported to the field. The bandoleers and modules help to automatically dispense seedlings in the visualized automatic transplanter. Seedlings are planted by placing them in a split, hollow tube, punching this tube into the soil, opening the tube halves and retracting the tube from the soil.

Technological Objective 4

Develop equipment and facilities to control environmental factors that affect crop production in greenhouses, in plant growth rooms and in the field.

Selected Examples of Recent Progress:

Liquid filter to selectively transmit photosynthetically active radiation tested - Beltsville, MD. Attempts have been made to build an acrylic double-wall tank chamber with a 3" thick filter of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ solution. It was found that 0.2% CuSO_4 solution will produce a cut-off point at 760nm. Preliminary data were obtained on operational procedures from the first chamber for four weeks. Growth responses of soybean seedlings were also obtained. Improved chambers and test procedures are being developed.

Growth chamber with light-temperature cross-gradients being developed - Beltsville, MD. Construction of an orthogonal crossed-gradient chamber is 50% complete. A gradient of light, ranging from 10,000 ft-c of cool white fluorescent light to less, will be created perpendicularly to a gradient of air temperature, ranging between 90° and 50° F, in a plant growth area of 90 square feet. Completion anticipated mid-1978.

Ultraviolet lamp sources characterized in relation to sunlight for effects on plants - Beltsville, MD. A method for characterizing fluorescent ultraviolet (UV) sources and filter combinations comparable to standard sunshine ultraviolet was established. Improved UV action spectra for plants were devised and tested, using UV sources of differing spectral UV radiation. Arrays of UV luminaires were developed with computer-predicted irradiance patterns for greenhouse, outdoor, and growth chamber use. Predicted irradiance was within 10 percent of subsequent measurements.

Effectiveness of energy-efficient lamp sources for plant growth lighting evaluated - Beltsville, MD. In close cooperation with the Florist and Nursery Crop Laboratory, extensive tests were conducted in growth chambers to evaluate the relative effectiveness of Cool-White Fluorescent (CWF) and of Low-Pressure Sodium (LPS) used as a sole light source and with the addition in varying ratios of red (R), blue (B), and far-red (FR) both simultaneously and subsequently during the dark period. The addition of R and B were accomplished by selected fluorescent sources and filters to avoid the FR radiation inherent in incandescent and other sources.

For most plants LPS (mainly 589 nm radiation) can be used as the main light source to regulate photosynthesis. Lettuce and Saint Paulia require additional R to convert pro-chlorophyll to long lasting chlorophyll and the development of a visually green plant. B, R, and FR sources added simultaneously had little effect on total growth. FR

promoted stem lengthening. R added subsequently to the 16 hour main lighting was effective in promotion of long lasting chlorophyll, visually green plants, expansion of leaves, and suppression of stem elongation.

In greenhouses, experimental facilities were constructed to compare radiation from LPS supplemental light sources at 42 W/m^2 and 21 W/m^2 irradiance with High-Pressure Sodium at 42 W/m^2 . Comparisons of plant growth (wt) and development show that supplemental light is an energy transfer process, without spectral dependence, in the visible region. Therefore, supplemental lighting can be entirely supplied by the more energy-efficient sources HPS or LPS. The FR requirements of plants were supplied by daylight. Twenty-five of 34 species gave equal or better growth when supplemental lighting was supplied during the night.

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Special Research Program (under NRP 20160)

PRODUCTION AND CONTROL OF NARCOTIC PLANTS

This Special Research Program works to affect the production economics of illicit narcotic crops so as to give licit agricultural enterprises a competitive advantage and, secondly, assure that the United States has an adequate and stable supply of raw materials to meet its medical needs for codeine at reasonable cost.

NPS Contact: Quentin Jones

PACS Contact: L. L. Jansen

Technological Objective 1.

Reliable research information on agricultural enterprises which will provide economically viable alternatives to growers of illicit narcotic crops.

Research Locations:

1103	Beltsville, Maryland
0203	Islamabad, Pakistan
0203	Chiang Mai, Thailand
0709	Ankara, Turkey

Selected Examples of Recent Progress:

Crop substitution for opium poppy - Islamabad, Pakistan; Chiang Mai, Thailand; and Ankara, Turkey.

In Pakistan research to develop domestic source of sugarbeet seed and seed potatoes to avoid foreign exchange is progressing well. Either of these crops can replace illicit opium poppy.

In Thailand, strawberries, peaches, pyrethrum, essential oil crops, and selected ornamentals have been designated for concerted effort in extending them to farmers fields. Price paid to farmers for illicit opium has dropped materially in last several years. This has brought pressure for viable alternative crops. Coffee (Coffea arabica) has done very well in Thailand but care must be taken to avoid planting coffee rust susceptible stock.

In Turkey demonstration plantings in 61 different villages in the poppy growing areas were made of new winter crop varieties. These included lentils, wheats, barleys, oats, safflowers, cephalaria, and ryes. All of these are superior to presently grown varieties.

Technological Objective 2.

New and improved knowledge of the botany, chemistry, and agronomy of narcotic plants and their products.

Research Locations:

5502	Tucson, Arizona
0710	Bloomington, Indiana
0709	Rehovot, Israel
1103	Beltsville, Maryland
0709	Corvallis, Oregon
1402	Philadelphia, Pennsylvania
5802	Pullman, Washington

Selected Examples of Recent Progress:

Improved cultural practices for *Papaver bracteatum* - Tucson, AZ; Rehovot, Israel; Beltsville, MD; Corvallis, OR, and Pullman, WA.

In Arizona pollination by honey bees materially increased seed set but had little effect on the thebaine levels in the capsule tissue. The average size/weight of capsule material was increased when proper pollination occurred, thus increasing the overall total production of thebaine per capsule and per unit area. Thebaine was not found in honey or pollen inside the hive or on bees working the flowers. The poppy is not a nectar producer. Bees are collecting large quantities of pollen for brood cells. There need be no concern about the bee colony damage or honey contamination from bees working the flowers of *P. bracteatum*.

In Israel sowing *P. bracteatum* in early summer under plastic net produced good stands of high quality seedlings as early as the end of August. mid-October seeds could be sown directly in the field without artificial shade. The number of capsules on *P. bracteatum* plants ranged up to 20 per plant and thebaine content from 0.4% to 5.0% on a dry weight basis.

At Beltsville plant density studies with *P. bracteatum* showed that plants spaced 30 to 60 cm apart produced 1.5 and 5.8 times more thebaine respectively in the second year (1976) than in the first year planted (1975). The 15 cm spacing produced relatively less in the second year because of intra-specific plant competition. The severe winter of 1976-1977 killed many plants and this study was discontinued.

At Corvallis, date of planting had no significant effect on total capsule yield. Row spacing and plant spacing significantly effected the number of capsules, total capsule yield, capsule weight and seed yield of 20-month-old poppy plants. While plantings established without good weed control did not flower the first year, those established with weed control produced both capsules and seed in 12 months.

At Pullman the thebaine content of the first capsule produced by a *P. bracteatum* is erratic and nonuniform. This is also true of the capsules

developed near the last of the season. The best estimate of the thebaine content of the capsules on an entire plant is obtained from those initiated at the time of peak flower production.

Ultrastructure of laticifers in Papaver - Bloomington, IN. Studies show the ultrastructure of differentiating laticifers in P. bracteatum is apparently identical to that of P. somniferum laticifers. Laticifers in both species contain large, irregularly shaped vesicles, several organelles including a single nucleus in each cell, mitochondria, dictyosomes, endoplasmic reticulum, lipid droplets, abundant ribosomes and plastids. The laticifers become interconnected into an anastomosing latex vessel network which extends throughout the plant. In this latex delivery system, the phenanthrine alkaloids are believed to be synthesized and stored in the vesicles.

Biosynthesis of alkaloids in Papaver somniferum - Philadelphia, PA. Enzyme preparations isolated from the post chloroplast supernatant of P. somniferum seedlings catalyzed the decarboxylation reaction of the alkaloid precursors (¹⁴C labelled or unlabelled tyrosine and DOPA). The optimal formation of dopamine from the decarboxylation of DOPA was dependent on the presence of pyridoxal phosphate and Harmaline (a monoamine oxidase inhibitor). However, the decarboxylation reaction was in competition with another reaction, the oxidation of DOPA to dopachrome, which was mediated by polyphenoloxidase enzymes. The formation of dopachrome was quantitatively determined by a spectrophotometric method. Kinetic studies showed that the conversion of DOPA to dopachrome was rapid and not dependent on pyridoxal phosphate. The inhibition of polyphenoloxidase is under study in order to block this reaction so that other important enzymes (transaminase, hydroxylase, decarboxylase) that are involved in the biosynthesis of alkaloids can be studied.

Technological Objective 3.

Agricultural Chemicals and biological agents for control of illicit narcotic crops.

Research Locations:

0709	Rehovot, Israel
1803	Beltsville, Maryland

Selected Examples of Recent Progress:

Weed control in Papaver bracteatum - Rehovot, Israel, and Beltsville, MD.

In Israel the herbicide 'Ronstar' applied in concentration of 4 liters per hectare was effective for weed control in P. bracteatum and produced from slight to no injury to P. bracteatum plants.

In Beltsville results of preliminary field experiments indicate that fire, glyphosate, paraquat, asulam, and BASF-3510-7 appear promising for the control of weeds during periods in which P. bracteatum is dormant. Confirmatory studies are needed.

SELECTED PUBLICATIONS

Beltsville, Maryland

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Special Research Program

GENETIC VULNERABILITY

The mission of this SRP is to make visible and give emphasis to the common concern of 21 parent NRP's and 2 other SRP's to reduce the genetic vulnerability of crops to losses from pests and environmental stresses. The commodity programs, the basic science programs, the plant germplasm program, and the pest control programs all are intended to lead to the efficient production of high quality, nutritious, safe crops, well adapted to their environment and cultural practices, and so protected from pests and environmental stresses that losses would be held to a minimum. The program is especially designed to minimize the probability of catastrophic losses such as occurred during the southern corn leaf blight epidemic and to enhance our ability to recover quickly from any epidemics that may occur.

NPS Contact: C. F. Lewis

PACS Contact: L. L. Jansen

Technological Objective 1.

Improve the national system for collecting, maintaining, evaluating, documenting and distributing plant genetic resources chosen for systematic preservation.

Research locations^{1/}:

5602	Fort Collins, Colorado
7616	Miami, Florida
7707	Experiment, Georgia
7705	Savannah, Georgia
3408	Ames, Iowa
1100	Beltsville, Maryland
1205	Glenn Dale, Maryland
1308	Geneva, New York
5802	Pullman, Washington
3507	Madison (Sturgeon Bay), Wisconsin

^{1/} About 40 other sites where germplasm collections are kept.

Selected Examples of Recent Progress:

Cross-referenced to NRP 20160

Examples of recent progress for this technological objective is cross-referenced to NRP 20160, Plant Germplasm. Highlight of activities include (1) Design and partial implementation of national system of clonal repositories for fruit and nut crops, and (2) Design and partial implementation of a computer-assisted information system for managing the inventory of stocks and data in the National Plant Germplasm System, (3) Completion of plant

collecting trips for grasses, sugarcane, tomatoes, cotton, pecans, and tropical fruits, and (4) additional support for National Seed Storage Laboratory, the Regional Plant Introduction Stations, and selected curators of germplasm.

Of special significance was the reestablishment of the National Plant Genetic Resources Board (NPGRB) by Secretary's Memorandum No. 1875 Revised, February 23, 1978. --

"The task of the Board is to advise on the assembly, description, maintenance, and effective utilization of the living resources represented by crop cultivars, primitive and wild forms of our crops. These resources are necessary for plant scientists to have the genetic variability necessary to cope with problems of today and the future.

"The Plant Genetic Resources Board objectives are to advise the Secretary of Agriculture and officers of the National Association of State Universities and Land Grant Colleges in order to assess national needs and identify high priority programs for conserving and utilizing plant genetic resources including such things as collection, maintenance and description of genetic stocks, and utilization of the stocks in plant improvement programs.

"The duties of the National Plant Genetic Resources Board are (1) to inform themselves of domestic and international activities to minimize genetic vulnerability of crops; (2) to formulate recommended actions and policies on collection, maintenance and utilization of plant genetic resources; (3) to recommend actions to coordinate the plant genetic resources plans of several domestic and international organizations; (4) to recommend policies to strengthen plant quarantine and pest monitoring activities, and (5) to advise on new and innovative approaches to plant improvement."

The Assistant Secretary of Conservation, Research and Education was directed to submit to the Secretary, by July 1, 1978, a report with recommendations about ways in which these objectives could be achieved. The NPGRB met in Washington, D. C., on May 18 and 19 and devoted most of its time to editing and revising a draft of a report. The NPGRB expects to revise the draft once more and then, if possible, have a three-person subcommittee personally present the report with an executive summary to the Secretary at his convenience after July 1, 1978.

Technological Objective 2.

Increase understanding of taxonomic, cytological, cytogenetic, and biochemical relationships among plant genetic resources. This technological objective also cross-references to NRP 20160, Plant Germplasm. This technological objective goes much beyond the taxonomic nomenclature of plants. It includes knowledge of chromosome number, chromosome pairing and fertility of hybrids as well as genetic structure and genetic variability of species over two geographic ranges of their distribution. Knowledge of the genetic structure of cultivated plants and of their genetic relationships with closely related species is essential for effective planning and execution of plant improvement programs.

Research Locations:^{2/}

5205 Salinas, California
1211 Washington, D. C.
3311 Urbana, Illinois
3302 West Lafayette, Indiana
3408 Ames, Iowa
1100 Beltsville, Maryland
3402 Columbia, Missouri
3705 Lincoln, Nebraska
7803 Oxford, North Carolina
7802 Raleigh, North Carolina
3602 Fargo, North Dakota
7317 Stillwater, Oklahoma
1302 University Park, Pennsylvania
7711 Charleston, South Carolina
7302 College Station, Texas
5702 Logan, Utah
3507 Madison (Sturgeon Bay), Wisconsin

2/ Other sites to some degree.

Selected Examples of Recent Progress:

Cross-referenced to NRP 20160

Technological Objective 3.

Improve the national program to utilize plant genetic resources for the breeding of cultivars and breeding stocks with increased genetic potential for producing high yields of good quality product with minimum losses from pest and environmental stresses.

Research Locations:^{3/}

3/ To list research locations for this technological objective would be to list all those stations where plant breeding (Code 0512) in PARIS and CRIS is performed. A PARIS printout as of October 1977 is available; however, it does not seem useful to report the whole program here.

Selected Examples of Recent Progress:

Cross-referenced to the following NRP's:

20010 Fruits, nuts & specialty crops production
20020 Vegetable production
20030 Florist & nursery crops production
20040 Corn, sorghum & millet production
20050 Small grain production
20060 Cotton production
20070 Tobacco production

20080 Oilseeds production
 20090 Sugar crops production
 20100 Forage crops production
 20110 Range management
 20170 Physiology & biochemistry-plants

In considering examples of progress this past year by FR, SEA, a tally was made of variety and noncommercial germplasm releases. By commodity, or groups of commodities, the figures are:

Forages	12
Small grains	44
Fruits and nuts	7
Vegetables	23
Corn	6
Sorghum	3
Sugarbeet	47
Sugarcane	1
Soybean	11
Peanuts	2
Safflower	1
Cotton	8
Tobacco	<u>6</u>
TOTAL	171

An overview statement may be paraphrased from a FY 1979 visual prepared to support the SEA budget presentation. The visual was entitled "Plant breeding pays off." An estimate was made that over 400 new varieties were released each year by State and Federal agencies and by private seed companies. Of this total over 200 are developed through public agency, State and Federal cooperation. Several estimates indicate the genetic gain through the release of new varieties is about 1 percent per year, which, translated in crop value, is worth about \$500 million annually. Also on this point, at the Senate Hearings, the agency was asked to prepare figures to show trends in average yield per acre over the past 45 years. The table is reproduced below:

Average Yield per Acre

	<u>1930</u>	<u>1975</u>	<u>Unit</u>	<u>% Increase</u>
Wheat	14.2	30.6	Bushels	215
Rye	12.4	22.0	Bushels	177
Rice	46.5	101.0	Bushels	217
Corn	20.5	86.2	Bushels	420
Oats	32.0	48.1	Bushels	150
Barley	23.8	44.0	Bushels	185
Grain sorghum	10.7	49.0	Bushels	458

Average Yield Per Acre (Continued)

	<u>1930</u>	<u>1975</u>	<u>Unit</u>	<u>% Increase</u>
Cotton	157.1	453.0	Pounds	288
Sugarbeets	11.9	19.3	Tons	162
Sugarcane	15.5	37.4	Tons	241
Tobacco	775.9	2011.0	Pounds	259
Peanuts	649.9	2565.0	Pounds	395
Soybeans	13.4	28.4	Bushels	212
Snap beans	27.9	37.0	Cwt	133
Potatoes	61.0	251.0	Cwt	229
Onions	159.0	306.0	Cwt	192
Tomatoes	61.0	166.0	Cwt	272
Hops	1202.0	1742.0	Pounds	145

A graph of average annual yields for each crop would have many ups and downs which could be accounted for primarily by weather; however, the trend lines have been steeply upward. There is evidence that some crop yields are beginning to plateau. Consumer demands require that we achieve equivalent or better gains in the next 45 years. Increased research on the biological processes of plants and plant pests will be required to put genetically superior crops in the field and protect them against pests and environmental stresses.

Factors influencing yield of a modern crop variety are complex. Fundamentally, yields per unit input of land, labor and energy can be increased in two ways. One is by breeding or increasing the inherent potential of the crop to produce. The other is to provide the growing crop with as favorable an environment as possible, so that the inherent potential is realized. The proper integration of genetic potential with other means of insect and disease control, weed control, use of fertilizer and irrigation, timely and efficient cultivation and harvest, and other management activities are essential to continued yield increases. As crop production systems increase in complexity, it is essential that the genetic yield potential keeps pace, but it is equally important that the genetic diversity is broad enough to avoid losses due to pest outbreaks and to minimize the effects of annual weather fluctuations. Weakening of a single component may greatly depress overall yields as illustrated by the corn blight situation in 1970.

Technological Objective 4.

Develop improved methods for control and management of pests.

Research Locations:^{4/}

Cross-referenced to the following NRP's:

- 20220 Insect control-horticultural crops
- 20230 Insect control-cotton & tobacco
- 20240 Insect control-field crops

20250 Insect control-basic/non-commodity
20260 Bio-control & insect identification
20270 Disease & nematode control-crops
20280 Weed control
20290 Pesticides & growth regulators

Cross-referenced to SRP's:

Pilot testing of alternative methods
for pest control
Minor use pesticides

Selected Examples of Recent Progress:

A review of the characteristics of new varieties released this past year shows that nearly all mention that the varieties were resistant to pests or environmental stresses. Included were the following:

	<u>Resistant to:</u>
Tobacco	black shank bacterial wilt Fusarium wilt root knot nematodes black rot brown spot wild fire tobacco mosaic black root rot tobacco etch virus
Wheat	green bug
Soybean	cyst nematode phytophthora root rot downey mildew
Peanuts	aflatoxin production
Safflower	lettuce mosaic virus Verticillium wilt Fusarium wilt phytophthora root rot hypocotyl rots
Sugarbeet	curly top virus Erwinia soft rot
Lima beans	anthracnose

	<u>Resistant to:</u>
Sweet potato	southern root-knot nematodes tropical root-knot nematodes northern root-knot nematodes Fusarium wilt
Tomatoes	curly top virus
Oat	barley yellow dwarf virus
Barley	acid soils
Rice	low temperature
Cotton	Verticillium wilt tobacco budworm bollworm
Corn	southern corn rust downy mildew
Bermudagrass	winterhardiness

The term, resistant, should not be confused with immunity. Resistance does not imply no damage, but that there is less damage than fully susceptible varieties would have. Host-plant resistance is not likely, per se, to offer satisfactory control for insects, although it is often the only effective control for plant pathogens. For insects, insect resistant varieties are likely to be a component of integrated pest management programs. Also the list of resistance factors above are just those specifically mentioned in recent releases. Varieties already on the market offer resistance to many pests and environmental stresses.

